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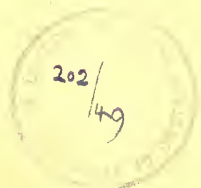
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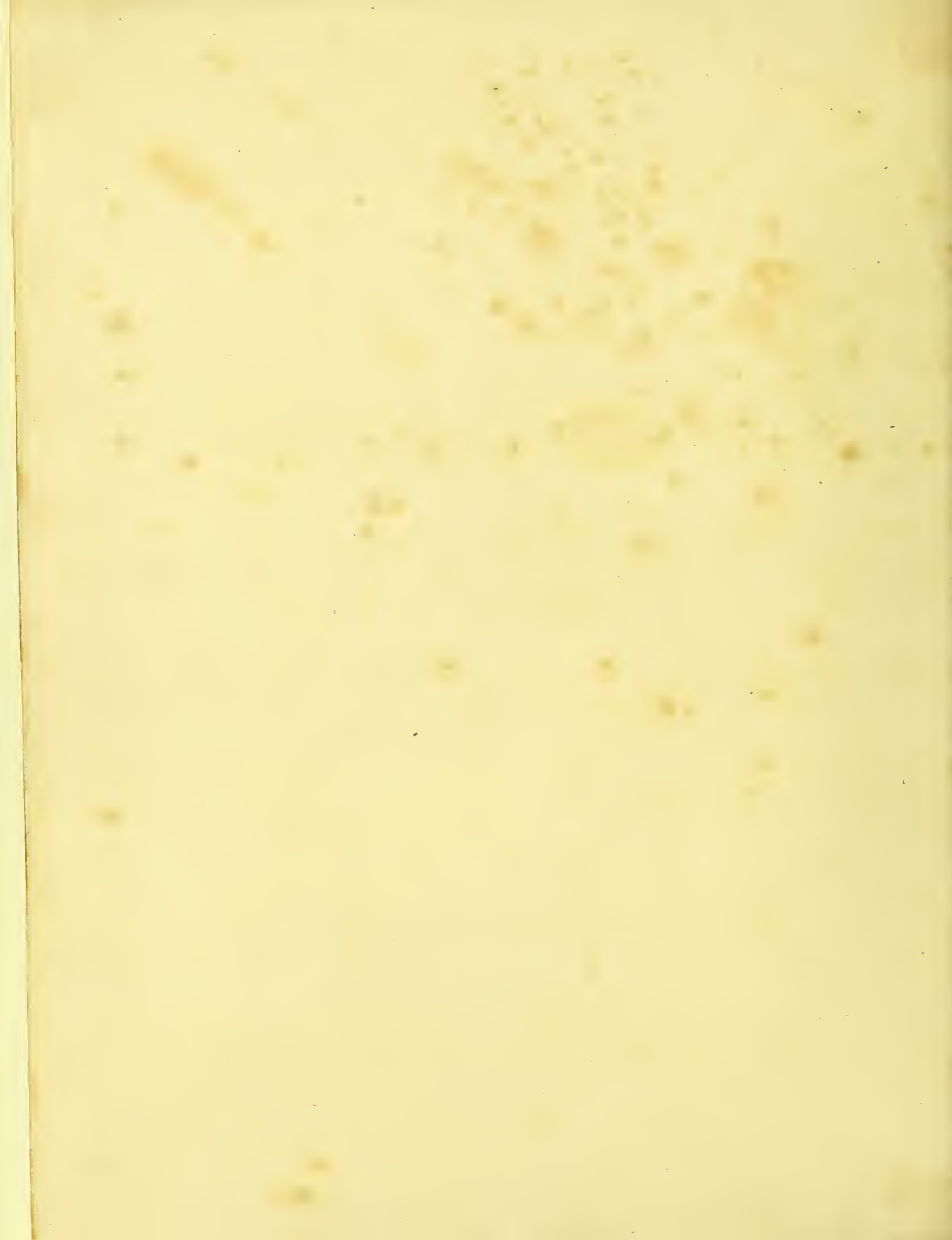


F. R. Gow at.

1872

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Robtson Henton

A
D I C T I O N A R Y

OF

C H E M I S T R Y,

Exhibiting the present State of the Theory and Practice of that Science, its Application to NATURAL PHILOSOPHY, the PROCESSES OF MANUFACTURES, METALLURGY, and numerous other Arts dependant on the Properties and Habitudes of Bodies, in the MINERAL, VEGETABLE, and ANIMAL KINGDOMS.

WITH A

CONSIDERABLE NUMBER OF TABLES,

Expressing the Elective Attractions, Specific Gravities, Comparative Heats, Component Parts, Combinations, and other Affections of the Objects of Chemical Research.

ILLUSTRATED WITH ENGRAVINGS.

By WILLIAM NICHOLSON.

IN TWO VOLUMES.

VOL. I.

LONDON:

PRINTED FOR G. G. AND J. ROBINSON, PATERNOSTER-ROW.

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P R E F A C E.

IT is usual for Authors to give an account, in a Prefatory Discourse, of the motives which may have induced them to compose such works as they present to the Public. Apologies for defects, and assistance to enable the Reader to discover excellencies, compose no small part of these Addresses. I have little to say in either respect. The Bookseller suggested to me, several years ago, his wish that I would compose a Chemical Dictionary. After some deliberation I engaged in the plan, from general as well as particular motives, which it is unnecessary to state, because sufficiently obvious. Since that time my progress has been interrupted, and at last suspended for many months, by misfortunes and ill health; the former of which, though to myself an impressive lesson of the bad principles of men in society, is too trite an instance of the evils produced by that cause, to constitute any part of the present Discourse. Neither of these can be urged in extenuation of the imperfections of the following work; but they are conclusive to justify the rectitude of the Author in the mind of such, if any there be, as may suppose him to possess the power or the ability to have done better.

The form of a Dictionary, though, for many years, in high estimation with the world in books on every subject, is confessedly inimical to the natural order of things. For this reason it seems proper to mention its advantages. When a subject does not, in itself, demand much of arrangement, or if the natural arrangement be such as not to be apprehended but by those who have made considerable advances in that department of knowledge, it is evident that the utility of a dictionary to the Learner will more than compensate for the offence given to the Masters of the Science. And accordingly it is found that no systematical arrangement of mere words or terms, with their explanations, can possess so much utility as that which follows the order of the alphabet. When Macquer's Dictionary first appeared, the Author remarked that Chemistry was little more than a collection of facts, scarcely entitled to the name of Science, or capable either of synthetic or analytic explanation. Whence he drew a just conclusion in favour of the Dictionary form. Since that time, the progress of Chemistry has, indeed, been uncommonly rapid. But if the Reader will contemplate the numerous blank compartments in the Tables at the

end of this work: if it be moreover considered, that the great controversy among Chemists, at present, which pervades the whole of the Science, amounts to a confession of ignorance whether in our theoretical explanations we ought to add or subtract; that the same principles, similar perhaps in all respects as to their nature and proportions, produce most of the striking differences between organized substances by the mere order of their combination; that scarcely a vestige of the means to ascertain this order has yet been discerned; that the absorption, combination, or emission of light, the existence and operation of heat in the latent state, the conducting powers of bodies, their densities, elasticities, refractive powers, and various other secondary properties, though they must all bear relation in some way or other to the habitudes which we call chemical, have been little attended to:—if these facts be duly considered, he will not be disposed to contend with me, when I affirm, that the arguments in favour of the Dictionary form possess nearly the same force, at present, as they did when Mr. Keir communicated that valuable mass of knowledge to the Public.

I have had some doubt whether I ought to advert to the Dictionary, of which this eminent Chemist has published a part: I mean the mere commercial consideration which presents itself between us. When any work is published, or in progress, it may seem unfair, that is to say wrong, for another Author to bring into the market a work of precisely the same kind. But this rivalry in trade, or in literature considered as a trade, has always appeared to me to be beneficial to the Public, and consequently justifiable, if conducted in such a manner as not to offend against the other universal principles which ought to regulate the conduct of every individual. At all events, however, the discussion of this case cannot apply to me. My Dictionary is comprehended within limits so much less extensive than those apparently exhibited in the first part of Mr. Keir's work, that the departments intended to be occupied by each must certainly be very distinct. I shall therefore dismiss this consideration with the sincere wish, that the world may soon be benefited by the farther labours of that Author in his great undertaking.

A less equivocal claim of justice presents itself with regard to the Authors from whose works the following compilation has been, for the most part, extracted. I have, on no occasion, scrupled to use the very words of the Authors, when the necessity of abridgement and interpolation, or the correction of error, have not required me to act otherwise. This is certainly the best, with regard to utility and accuracy, though it may perhaps be considered as a deduction from the Author's own claim to originality. On this last head I should have very little anxiety, even if the work were of a different kind; strict truth being of infinitely more value than any other consideration.

consideration. I have, therefore, been led to reject altogether the marks of quotation; but I have not neglected to mention my authorities, wherever it was necessary. It will be found, on close examination, that the practice of all Authors who have written on general subjects has necessarily been the same.

Though the Science of Chemistry possesses little of system, and it is accordingly found that the writers of general Treatises vary greatly in their arrangement of the subject, yet it is commonly supposed that a Dictionary of any Science is, or ought to be, a regular Treatise, broken into parts, and distributed under the Titles of an Index. A moderate portion of ingenuity will enable any one to select the articles of the following work, and distribute them into a kind of system. But I will confess that I have paid no attention to any such project. To me it seems calculated to produce a distracting set of references from one article to another, and to defeat the very purpose of a Dictionary, by requiring the Reader to consult a great number of articles, when his purpose was to see under one article the greatest part of what could be said on that subject. I have accordingly endeavoured, as much as the nature of things would permit, to make each article a concise Essay or Tract upon the subject under its title, and have thought it better to make occasional short repetitions, than oblige the Reader to refer to articles where the relative branches of the subject are more fully treated. The great number of references is by this means more naturally supplied by those short notices; and the Reader, if his purpose require it, will have recourse to the other articles without formal direction. The Index of Things is obviously useful for the same purpose.

A distinction is sometimes made, in experimental Science, between men of theory and men of fact. We are but too apt to run into extremes. The men of theory consider general results as the great and dignified objects of Science, and estimate the importance of facts according to their respective rank among the illustrations of their general theorems. The men of fact, on the contrary, are disposed to attach a high value to the practical department, and are much more attentive to register one incident after another, than to generalize and explain the operations they behold. The enlightened cultivator of Science will be neither of these exclusively, or rather he will be both. In the acquisition of knowledge, few men can patiently endure a state of doubt; and there are not many minds so cultivated and so powerful as to be aware of the seductions of a digested hypothesis, which continually presents its possessor with imaginary discoveries. But the ordinary effects of an attention to hypothesis are, that things, by frequent repetition, become associated in the mind, which have no real connection in nature; that such events as coincide with the theory make a stronger impression on the mind than those which

which do not, and accordingly the latter are either overlooked or rejected; and, lastly, that this false coincidence of theory and fact becomes one of the strongest arguments in its favour. Hence we see, in religious, moral, and metaphysical controversies, as well as in those that relate to physical objects, converts are seldom produced by the direct force of right reasoning; but in an indirect method, from the repetition of their adversaries' arguments, with a view to confute them. It seems necessary, when the mind is thus misled, that an equal force of habit should be practically generated in favour of the opposite side of a controversy, before impartiality can be produced. The man who has been habituated to explain chemical phenomena by the doctrine of phlogiston, will not be an impartial judge in that controversy, until he has acquired a facility in explaining them by the doctrine which rejects that principle.

It appears then to be of the utmost importance, that every man of Science should acquire sufficient fortitude to enable him to perceive the narrow limits of his own knowledge, and the numerous objects which require investigation. Vanity may be flattered by the specious pretence of accounting for every thing; but even this principle of self-approbation may be much more highly gratified by the effects of that energy of mind, which is produced by the contemplation of truth, abstracted from all fiction. More than half of our lives is employed in discriminating and unlearning error. How much more effectual would our efforts then be, if, by timely examination and reasonable doubt, we had continued in the situation of being able to receive and apply the truth whensoever presented to us! It is affirmed that, in Chemistry, even a bad theory is of use to methodise and arrange facts. But this cannot be true; for bad theory, that is to say falsehood, cannot promote the ends of truth: So far as the theory agrees with the truth, it will consist of arrangement growing out of the nature of the facts themselves; and so far as it differs from this, it is delusion.

Under the impression of these and other fundamental principles, I have been disposed to set very little value upon the ingenious conjectures presented to the Public respecting the Theory of Chemistry by a considerable number of men of ability. I have uniformly endeavoured to distribute the facts in such a manner that they may tend to explain themselves; and in the few articles where I have had occasion to give an account of the theories of others, I have never scrupled to distinguish the weak parts from the strong. Many things are therefore related as matter of doubt, concerning which a large number of Chemists entertain no doubt whatever.

In the controversy respecting Phlogiston, or the nature of Combustion, not a little remains to be done, before it can be said that the process is well understood. I have asserted under the latter article,

that

that the doctrine which rejects phlogiston, or a common inflammable matter, appears to me to be much the most simple, and consequently probable. But I have not adopted the nomenclature of the Anti-phlogistians. We are so continually misled by words that it would, no doubt, be of great advantage if a consistent and uniform nomenclature were generally adopted. The French nomenclature, though not without its faults, appears to be more perfect than any other which has been offered : but I did not think myself at liberty to anticipate the public choice, by using it in an elementary work.

With regard to the materials, to which I have had recourse, I do not here enter into any detail. It would be of little use to the Beginner, and the Man of Science will scarcely need the assistance of the Index of Names to ascertain the principal sources of my information. Those only who may have undertaken the laborious task of bringing together, in one mass, the various facts of a Science scarcely methodised, which lie dispersed through the Acts of Academies, Literary Journals, and Treatises in various languages, will be truly aware of the probabilities of error or imperfection in such an undertaking. A considerable portion of these materials must in the nature of things be inaccessible, or unknown, to the Compiler; and the utmost industry of compilation must also have its limits. Human undertakings require to be accomplished within some definite time, otherwise their utility would suffer from the changes which take place even during the performance. I will not here express any useless wish, that my researches had been more fortunate, or my resources more extensive. Every man of reflection will do justice to my endeavours in this respect, and I ought to claim no more.

Enumeration of the TABLES contained in the present Work.

	Page
I. <i>SIMPLE</i> Elective Attractions, from Bergman, in Six Tables —	166 to 171
II. The numerical Expression of Affinities, by Morveau — —	172
III. Schemes of Compound Elective Attraction, exhibited by Position in the humid and dry Way; being Fifty-two Instances, translated, with some Alterations, from the Symbols of Bergman	176—187
IV. Weights of different Countries compared with those of France and England, by Tillet — —	195
V. Specific Gravities of Bodies, and Weight of a Cubic Inch of each in Pounds Averdupoise — —	366
VI. Comparative Heats of different Bodies — —	381
VII. Specific Gravities corresponding with the Degrees of Baume's Hydrometer — —	389
VIII. Nomenclature of the French Chemists — —	524—529
IX. Quantity of Essential Oil afforded by different Vegetables —	535—538
X. Alkaline Products from Vegetables by Incineration —	678, 679
XI. Quantities of Precipitate afforded by the several Metals to the different Alkalis — —	705, 706
XII. Quantities of the Oxygenous Principle required to render 100 Grains of each of the Metals soluble — —	715
XIII. Elevated Temperatures and their Effects, expressed in Degrees of the Thermometers of Wedgwood and Fabrenheit —	751
XIV. Strength and Specific Gravity of Ardent Spirit, according to Bories — —	867
XV. Specific Gravities of Distilled Water for every five Degrees between 30 Degrees and 100 Degrees, by Mr. Gilpin —	873
XVI. Specific Gravity of Ardent Spirit for every five Degrees of Temperature between 30 Degrees and 100 Degrees, and for all Strengths intermediate between pure Spirit and Water by Mr. Gilpin — —	875
XVII. Names and Quantities of Salts soluble in Ardent Spirit —	879
XVIII. Materials and Products of Fermentation, tabulated by Lavoisier — —	881—883
XIX. Quantities of several Salts soluble in Water —	1016, 1017
XX. Binary Combinations of Principles not hitherto decomposed —	1074
XXI. Compounds consisting in general of more than Two Principles	1076—1093
XXII. Compounds of certain Products of Organization — —	1094
XXIII. Table of the Correspondence of the Thermometers of Fabrenheit, Reaumur, and Celsius — —	1095

A

D I C T I O N A R Y

O F

C H E M I S T R Y.

A B S

ABSORBENT. The more soluble earths were formerly distinguished by the name of absorbent earths. This division comprehended clay, lime, and magnesia; but modern chemists have justly rejected it as vague and indefinite.

ABSTRACTION. In the process of distillation, the volatile products which come over and are condensed in the receivers, are sometimes said to be abstracted from the more fixed part which remains behind. This term is chiefly used when an acid or other fluid is repeatedly poured upon any substance in a retort, and distilled off, with a view to change its state, or the nature of its composition. See **DISTILLATION**.

ACESCENT. A substance which becomes sour or acid by spontaneous decomposition, is said to be acescent.

ACETOUS. Of or belonging to vinegar, or the acetous acid. See **ACID**, **ACETOUS**.

ACHROMATIC. Telescopes formed of a combination of lenses, which in a great measure correct the optical aberration arising from the various colours of light, are called achromatic telescopes. Some of these have been made wonderfully perfect, and their excellence appears to be limited only by the imperfections of the art of glass making. The artifice of this capital invention of *Dollond* consists in selecting, by trial, two such pieces of glass, to form the object lenses, as separate the variously coloured rays of light to equal angles of divergence, at different angles of refraction of the mean ray; in which case it is evident, that, if they be made to refract towards contrary parts, the whole ray may be caused to deviate from its course without being separated into colours. The difficulty of the glass-maker is

in a great measure confined to the problem of making that kind of glass which shall cause a great divergence of the coloured rays with respect to each other, while the mean refraction is small. See GLASS.

ACID. In the infancy of any science, when the attention of its cultivators is chiefly employed upon substances which differ from each other by great and obvious variations, it is easy to establish criterions, by which the classification of bodies may be effected: but when any particular branch is carried to a considerable degree of perfection, there will always be found a variety of articles which form a connection between one class and another, and render it difficult to draw the line of discrimination. Acids were formerly distinguished by the popular criterion of taste which is peculiar to them, and is denoted by the word *sourness*. Modern discoveries have, however, exhibited acids, in which the leading properties are too obscure to be of any great utility in determining their nature when unknown; and it is only from the general assemblage of properties that they can be distinguished. These properties are,

1. Their taste is sour and corrosive, unless diluted with water.
2. They change blue vegetable colours to a red.
3. Most of them unite with water in all proportions; and many have so strong an attraction to that fluid as not to be exhibited in the solid state.
4. At a moderate temperature, or in the humid way, they combine with alkalis so strongly as to take them from all other substances.
5. They combine with most bodies, and form combinations attended with many interesting phenomena; upon the due explanation of which a great part of the science of chemistry depends.

There are a considerable number of instances in which combustible substances are converted into acids by being burned. Thus sulphur, by combustion, affords vitriolic acid; phlogisticated air, repeatedly ignited by electricity, affords nitrous acid; and phosphorus, by burning, is converted into phosphoric acid. The analogy of other facts appears to justify the general position, that acids consist each of a peculiar basis, altered by combustion; and, as it is now generally admitted that the vital or truly respirable part of the atmosphere is absorbed during combustion, it will follow that an acid consists of a combustible substance united with vital air.

This is indeed the simplest way of stating the result. But it is of the greatest importance, in scientific pursuits, to be cautious in simplifying our deductions. General hypotheses are most commonly constructed, by overlooking such concomitant circumstances in natural events as are least striking; but which, nevertheless, cannot be reasoned out of the course of the actual processes. When this expedient is used to obtain a delusive shew of simplicity, the business of enquiring into the phenomena which are exhibited around us, degenerates into a war of words, and the facts are no longer impartially displayed; such facts being always esteemed of greatest value as seem most effectual in supporting the favourite system. It must be confessed, however, on the other hand, that all useful investigation must necessarily tend to the discovery of general truths, and the development of the simple laws of nature; that systems, formed in the less perfect state of any science, will of course be founded on fewer facts, and will, by successive emendation, become more and more complicated; and, consequently, that the real improvement of any theory will almost always consist in the rejection of principles formerly held to be essential to the science.

The chemists of France consider combustion as a mere union of vital air with any inflammable substance. Most of the chemists in England and Germany suppose one general principle of inflammability, called phlogiston, to exist in all bodies

bodies which are susceptible of burning, and they maintain that combustion is a disengagement of phlogiston. The discovery that vital air is absorbed in this process, has rendered the ancient theory less simple. Phlogiston was formerly a being of great use, in solving the appearances that take place in all bodies by burning; and its existence was therefore inferred from the facts to which it was applied; but at present it embarrasses the chemist in various instances, and has been disposed of hypothetically, according to the fancy of the theorists. Some affirm, that the vital air combines with the base of the combustible body, while the phlogiston is disengaged and flies off: others assert, that vital air unites with phlogiston only in all cases of combustion; so that there are two effective causes of this phenomenon; namely, phlogiston, and air. An acid may therefore be considered as composed of a combustible basis, united with vital air; or as the same base, first deprived of phlogiston and then united to vital air; or as a combination of the basis, together with phlogiston and vital air, which, in some instances, the phlogistic philosophers find it necessary to suppose; or, lastly, if the vital air be assumed to be a compounded body, and its parts be supposed to consist of the general principle of acidity, combined with fire or the matter of heat, it is evident that we shall have proceeded still farther into the regions of hypothesis, and the variety of possible arrangements will be greatly multiplied. The writings of modern chemists are filled with disquisitions founded upon assumed combinations of this nature.

Several ingenious attempts have been made to ascertain the strength of acids, and the real quantity of saline matter contained in such as cannot, by any means hitherto devised, be deprived of water. Both these objects are very difficult to be obtained, and the latter, more especially, does not seem to be determinable by any other process than such as shall actually leave the acid in a pure state, without the presence of water or any other substance. The prospect of this appears to be so unpromising as almost effectually to discourage any attempts at performing it. The former enquiry seems to be within our power, provided the determination of the strength of acids be understood to imply nothing more than to deduce a method of ascertaining the quantity of acid, of a given density, which may be contained in any given measure of the same acid, more or less diluted with water. Experiments carefully made, by adding certain regulated quantities of water to equal portions of the densest acids, will exhibit a series of densities or specific gravities, which, being tabulated, will serve to indicate the quantities of the densest acid which may be contained in any other portions of the same acid examined at the temperature of the original experiments, or with a due allowance for any variation between the temperatures.

The usual method of ascertaining the comparative strengths of different acids, consists in saturating them with alkaline salt; that acid being supposed the strongest which requires the greatest quantity of alkali to cause the total disappearance of its acid properties. Against this, however, it is an insurmountable objection, that the acids do not differ from each other merely in strength, as estimated by this criterion, but are principally distinguished from each other by their several attractions to other substances, which follow no constant law deducible from experiments made with alkalis. So that the acid which requires the greatest quantity of alkali for its saturation, will not maintain the same precedence when applied to earths, metals, or combustible bodies. As the method of examination by alkalis may nevertheless have its uses, especially in acids of the same kind, it is proper to observe, that the mineral alkali in pure crystals, suffered to fall into efflorescence, and then dried in similar circumstances for

a determinate time by the heat of boiling water, is the best substance for affording a constant result. It must be preserved in a dry bottle well closed.

At first consideration it may seem an easy matter to determine the quantity of acid in any measure of fluid, by saturating it with alkali, and crystallizing the neutral salt by evaporating the water. This method must be allowed to possess some advantages, though it is pressed with difficulties of considerable magnitude. It is by no means easy to ascertain the quantity of an alkali. The mineral alkali, just spoken of, contains a large quantity of fixed air, which being pretty constant, may not, indeed, prevent the alkali from being used to obtain proportional results; but it must be driven off when the absolute quantity of alkali is the object of enquiry; and the alkali, thus treated by fire, will in most, if not all, cases dissolve a portion of the vessel, and, from its strong tendency to attract moisture from the air, will be very difficult to be weighed. A careful operator may, however, get over these obstacles, by weighing the earth deposited during the combination of the alkali with the acid, and this weight of earth being deducted from the weight of the hot alkali, previously ascertained in a closed bottle, will leave the real weight of the alkali itself: but, after this proceeding, the neutral salt will differ in its weight, according to the quantity of water which enters into the formation of its crystals; for this quantity will be greater, the lower the temperature at which the crystals were formed: so that, in the course of evaporation and cooling, the crystals will contain more and more water, according to the order of their deposition. The best method of rendering the water of crystallization a constant quantity seems to be, to evaporate on a water bath, and let the neutral salt separate without exposing the fluid to the lower temperature.

The acids hitherto discovered are distinguished according to the mineral, vegetable, or animal kingdoms from which they are obtained. The mineral kingdom affords, 1. the vitriolic acid, known in commerce by the name of oil of vitriol; 2. the nitrous acid, called spirit of nitre; 3. the marine acid, called spirit of salt; 4. the aerial acid, or fixed air; 5. the acid of borax, or sedative salt; 6. the acid of fluor spar, or sparry acid; 7. the acid of amber, or succinous acid; 8. the acid of phosphorus, or phosphoric acid; 9. the acid of arsenic; 10. the acid of tin; 11. the acid of molybdena; 12. the acid of tungsten, or wolfram.

The vegetable kingdom affords the acids, 1. of lemons; 2. of apples, or unripe fruits; 3. of galls; 4. of benzoin; 5. of tartar; 6. of sugar, or sorrel; 7. of mucilage, or sugar, by destructive distillation; 8. of tartar, and 9. of wood, by the same process; 10. the acid of camphor; and, 11. the acetous acid, or vinegar.

The animal kingdom affords the acid, 1. of milk; 2. of sugar of milk; 3. of ants; 4. of Prussian blue; 5. of fat; 6. of the stone of the bladder; and, 7. of silk-worms.

ACID, ACETOUS. Vinegar is an acid, formed by that spontaneous change which takes place in organized substances, and is distinguished by the name of fermentation. For the circumstances and requisites necessary to produce this acid, *see* the words **FERMENTATION**, and **VINEGAR**. When vinegar is exposed to distillation, a watery fluid first rises, which is scarcely acid, but possesses the lively smell of the vinegar itself; this is succeeded by the acid which chemists call the acetous acid, and in commerce is called distilled vinegar. The acid reserved as distilled vinegar must not exceed two-thirds of the whole, because the action of the heat begins to produce a considerable change in the remaining principles on the retort.

Distilled

Distilled vinegar is much diluted with the water which comes over with it, and these two fluids do not sufficiently differ in volatility to admit of the acid being concentrated, by expelling the water by a graduated heat. A large portion of this water may, however, be separated, by exposing the fluid to a freezing atmosphere : for the water congeals first, and may then be taken out : the remaining strong acid may be rendered exceedingly pure, by several rectifications on a water bath, which deprive it of such extraneous and oily parts as may have passed over in the first distillation. At the beginning of the rectification, a very spirituous fluid passes over, which, being separated and rectified by itself, yields a true and fine ether, of a very pleasant smell, and immiscible with water ; which ether may be added to the purified acid of the other rectifications. In this process * it is essential to preserve the phlegm which passes over in the first distillation, because it contains the most fragrant parts of the fluid, and ought, therefore, to be added to the rest of the distilled product exposed to congelation.

The acetous acid obtained in the foregoing process seems to be the true concentrated acid, though there may, perhaps, be found reasons to doubt whether the frequent exhibition of the vaporous form may not have caused it to imbibed some principle from the atmosphere. In the other methods of concentrating this acid, there appear sufficient reasons to conclude that this really happens : these operations consist in combining the diluted or weak acetous acid with an earth, alkali, or metal, and afterwards driving it off by distillation from the crystallized or dry salt. In many, and perhaps most instances of this kind with acetous acid, the combination is attended with the absorption of vital air from the atmosphere, which greatly increases the activity of the acid ; and accordingly the acid afforded in distillation has very different properties from those of distilled vinegar, even when both acids are equally diluted : thus the acid called radical vinegar, obtained by distillation from the saline combination of vinegar and copper, which is improperly called distilled verdigrise, differs greatly from the vinegar made use of ; and as the combination does not take place, unless respirable air be absorbed, it follows from this, as well as other circumstances, that pure radical vinegar possesses a higher degree of acidification in consequence of its having absorbed vital air.

As the acetous acid has been long known to chemists, its combinations with earths, alkalis, metals, and other bodies, will be noticed under the respective articles ; and for its formation, and the inductions of philosophers concerning its component parts, *see* the word VINEGAR.

ACID, AERIAL. This name was given by Bergman to the acid which is most commonly distinguished by the name of fixed air. This last term, indeed, carries nothing distinctive in it, since it has been discovered that all permanently elastic fluids, or airs, may be fixed by combination with other bodies ; besides which, as the qualities of this acid are as often the subject of enquiry in its elastic as in its fixed state, there is an evident impropriety in the appellation *fixed* ; nevertheless, as chemists are not agreed in the use of any other term, we think it proper to conform to the name generally adopted. See AIR, FIXED.

ACID OF AMBER. When amber is submitted to distillation by a graduated heat in a retort, the products are first a reddish acid phlegm, which smells strongly of the amber ; next a volatile acid salt, which sublimes and forms small white or yellowish needles that occupy the neck of the retort ; this is succeeded by a white volatile oil of a pungent smell, but which becomes browner, more viscid, and empyreumatic, as the distillation proceeds : and the residue is a black, brittle, bitumi-

nous

* Of Lowitz. See Kier's Dictionary, p. 32.

nous mafs. It is the white fublimed falt which is diftinguifhed by the name of the acid of amber, and requires to be further purified by repeated folutions and cryftallizations. A pound of amber does not afford more than half an ounce of this falt.

The acid of amber is foluble in twenty-four times its weight of cold water, and in a much lefs quantity when boiling hot. Boiling fpirit of wine takes up more than one-third of its weight, of which a confiderable portion feparates in cryftals by cooling. Vitriolic acid diffolves it, as do likewife the nitrous, marine, acetous, and regaline acids, by the affiftance of heat; but it may be again feparated from them without alteration. Mere heat fublimes it at a higher temperature than raifes the volatile alkali. The addition of nitre caufes it to detonate, but the aerial products of this detonation have not been afcertained.

The acid properties of this falt are exhibited by its tafte, by its giving a red colour to litmus, or heliotropium, and to fyrup of violets, and alfo by its combining with alkalis, earths, and metallic calces, with which it forms peculiar faline compounds.

When a folution of vegetable alkali is faturated with the acid of amber, and flowly evaporated, it affords a neutral falt in white transparent cryftals, which have a bitter tafte, are eafily foluble in water, and deliquefce in the air: in the fire they decrepitate and melt, but the acid is not driven off, unlefs perhaps by a very ftrong heat. The neutral falt formed in the fame manner with this acid and the mineral alkali poffeffes nearly the fame properties, excepting that they do not attract humidity when expofed to the air. The combination of volatile alkali with acid of amber fhoots into needle-formed cryftals, which deliquefce in the air, evaporate totally when heated in a filver fpoon, and fublime entire by heat in clofed veffels.

Lime and ponderous earth both form falts of very fparing folubility with this acid: magnesia forms with it a white faline mafs of a gummy confiftence, which becomes yellowifh when dried by the fire, but afterwards attracts moifture from the air. Clay and the acid of amber form a falt in prifmatic cryftals.

The various experiments neceffary to afcertain the habitudes of the acid of amber with metals have not been yet made and duly verified. Gold and platina have not been tried. Silver is not acted upon in its metallic ftate; but if it be previoufly diffolved in another acid, and precipitated by the addition of an alkali, the precipitate will combine with the acid of amber, with which it forms long thin cryftals, which part with their acid to alkalis, and alfo to filver and copper. Copper, in its metallic ftate, forms with the acid of amber a green folution that affords cryftals. Lead is not acted upon in the metallic ftate; but its precipitate by alkalis is diffolved, and affords cryftals: the lead may be precipitated from this folution in the metallic form, by the addition of zinc, or in the form of a grey calx, when an alkali is added. Iron and its precipitates are diffolved in this acid, and the latter afford cryftals. Tin is taken up, but falls again in the form of a white calx. The precipitate of this metal from an acid by an alkali is alfo foluble in acid of amber, and affords, by evaporation, broad, foliated, transparent cryftals. By digefting the precipitate of mercury by an alkali, for fome days, in acid of amber, a fhapelefs faline mafs is obtained, from which the mercury is precipitated in very fmall quantities by alkali, copioufly by liver of fuphur, and in its metallic ftate by copper. Zinc is readily diffolved in its metallic ftate by this acid: the folution of precipitate of zinc, obtained by alkalis, affords cryftals. Bifmuth, and its precipitate by alkalis, are likewife foluble, and the latter cryftallizable. None of the known

metallic combinations of this acid are deliquescent, and they all give out their acid by distillation.

For the order of the attractions of this acid, *see* ATTRACTION, ELECTIVE.

ACID OF ANTS. These insects contain an acid, which they either discharge when irritated, or moisten their fangs with it, to render their bite more painful: it may be obtained from the ants, either by simple distillation, or by infusion of them in boiling water, and subsequent distillation of as much of the water as can be brought over without burning the residue: it may be purified either by repeated rectifications carefully managed, or by boiling to separate the impurities; or it may, after rectification, be concentrated by frost, which separates part of its water in the form of ice. If it be saturated with fixed alkali, then filtered, evaporated, and distilled with half its weight of concentrated vitriolic acid, a very clear strong acid comes over. The acid of ants obtained in this way may, however, with great justice, be suspected of having suffered a change in its properties, of the same nature as that which vinegar is subject to, when converted into radical vinegar by a like process. (See page 5.)

The acid of ants exhibits all the usual criterions of acidity, such as reddening blue vegetable colours; it renders the vitriolic acid black, and gives the yellow colour and fuming quality to pale nitrous acid. When distilled with ardent spirit, it affords some indications of an ethereal product; and the concentrated acid, obtained from its alkaline combination with alkalis, affords a large proportion of ether with ardent spirit. This appears to shew that the latter acid is altered by the process it has undergone, during which it probably becomes more completely acidified, by absorbing a greater portion of vital air.

The acid of ants unites with fixed vegetable alkali and forms a neutral salt in deliquescent crystals, from which the acid may be driven by heat, though not in its entire state; for the heat requisite for that purpose is so great, that the acid is decomposed, and affords fixed air and inflammable air. With mineral alkali this acid forms a very soluble, crystallizable, deliquescent salt, which is suspended in twice its weight of water: its combination with volatile alkali is so greedy of water, that it cannot be exhibited in the crystalline form but with great difficulty.

Acid of ants, combined with lime, affords permanent crystals soluble in eight times their weight of water, and of a bitter taste; magnesia is attacked by it, and forms an insipid crystalline salt, soluble in thirteen parts of water. Ponderous earth afforded permanent crystals, soluble in four parts of water; and pure clay, or earth of alum, unites with difficulty with it. None of these combinations are soluble in ardent spirit.

This acid dissolves iron and zinc very readily, but its action on copper is weak: it scarcely acts at all upon silver, lead, tin, regulus of antimony, bismuth, mercury, arsenic, cobalt, nickel, and gold, but it dissolves their calces: it does not act upon the calx of platina. The salts formed by the calces of silver, copper, lead, bismuth, and mercury, are crystallizable.

ACID OF APPLES. The acid which abounds in four or unripe fruits exhibits distinct properties: as it is plentifully obtained from apples, the first examiner, Scheele, has denominated it the Acid of Apples. In order to obtain it, the juice of four apples is expressed from the fruit, and saturated with vegetable alkali. To this liquor a solution of the vitriolic salt of lead must be very gradually added: a double decomposition takes place; the vitriolic acid combines with the alkali, and forms vitriolated tartar, at the same time that the acid of apples, uniting with the lead, forms an insoluble precipitate. When the
pre-

precipitate nearly ceases to fall down, the solution of vitriol of lead must be added cautiously, a drop at a time, until no more precipitate is afforded: the vitriolated tartar may be washed off from the precipitate; and diluted vitriolic acid being then poured on the precipitate, sugar of lead is again formed, and the acid of apples is let at liberty.

In such fruits as contain the acid of lemons, as well as that of apples, the separation of one from the other is accomplished by the following process: The juice of gooseberries, for example, is evaporated to the consistence of syrup; pure ardent spirit being poured upon this, dissolves the acids, and leaves the mucilage, which may be separated by filtration: the ardent spirit being then evaporated, and water added, the acids must be saturated with chalk. The solution being boiled for a few minutes, the calcareous salt of lemons falls to the bottom, on account of its difficult solubility, while the other salt, consisting of the acid of apples united to lime, remains suspended, and may consequently be decanted off. This neutral salt not being soluble in spirit of wine, may be precipitated by the addition of a proper quantity of that fluid, which, at the same time, deprives it of a portion of saponeaceous and saccharine matter. The coagulum, or precipitate, which consists for the most part of the acid of apples, perfectly neutralized by lime, may be dissolved in boiling water. An addition of sugar of lead forms a precipitate by double affinity, as in the first case, consisting of the acid of apples united to lead; and this washed precipitate may be decomposed by the addition of diluted vitriolic acid, which combines with the lead, and sets the acid of apples at liberty.

This acid exhibits peculiar properties: it cannot be obtained in crystals, and forms deliquescent salts with the three alkalis, and also with magnesia. Its saline combination with lime is crystallizable; and with clay it forms a salt of very sparing solubility: it dissolves iron, with which it forms a salt that does not crystallize; with zinc it forms a salt which affords beautiful crystals. It precipitates the nitrous solutions of mercury, lead, silver, and gold, in the metallic state. When nitrous acid is repeatedly distilled from it, it is converted into acid of sugar.

ACID OF ARSENIC, or ARSENICAL ACID. The earlier chemists were embarrassed in the determination of the nature of the white sublimate which is obtained during the roasting of cobalt and other metallic ores, known in commerce by the name of arsenic: its solubility in water, its power of combining with metals in their reguline state, together with other apparently heterogeneous properties, rendered it difficult to determine whether it ought to be classed with metals or salts. Subsequent discoveries have shewn the relation it bears to both: when treated with combustible matter, in close vessels, it sublimes in the metallic form; combustion, or any analogous process, converts it into a calx; and when the combustion is carried still further, by the application of nitrous acid, the arsenical basis becomes itself converted into an acid.

We are indebted to the illustrious Scheele for the discovery of this acid, which may be obtained by various methods. Two ounces of the white calx of arsenic, reduced to powder in a glass mortar, are to be put into a tubulated retort, likewise of glass: upon this seven ounces of pure marine acid, of the specific gravity of 125, must be poured; the mixture must then be heated until the arsenic is dissolved, and then, while the solution is still warm, three ounces and a half of pure nitrous acid, of the same specific gravity, are to be added, together with what marine acid may have come over into the receiver; the receiver may then be again applied, but not luted, and the distillation continued. The mixture froths and emits red nitrous fumes, part of which are condensed in the receiver in coloured

or

or phlogificated nitrous acid. As soon as, in the progress of the operation, the red vapours have ceased to appear, an ounce of finely powdered arsenic is to be again added, and the solution effected as before, by a gentle ebullition. To this an ounce and a half of fresh nitrous acid, must be added, which will produce a second effervescence and discharge of red vapours: the distillation must now be continued to dryness, and the fire must be urged towards the end, to such a degree as to make the residual white mass thoroughly red hot. This mass is the dry acid of arsenic, which may either be preserved in that form in a closed vessel, or may be dissolved by boiling it for a few minutes in twice its weight of distilled water. The solution, after subsidence, or filtration through blotting paper, previously washed in hot water, is the liquid acid of arsenic.

This process consists in nothing more than a judicious application of nitrous acid to the white arsenic, which it acidifies either by the communication of vital air, the abstraction of phlogiston, or perhaps by both; but, in a word, by effecting the same change as is produced by combustion, whatever may be the theory of that process. As the white arsenic is scarcely soluble in nitrous acid, and as the violent effervescence produced by adding aqua-regia, or a mixture of marine and nitrous acid, to this substance, is found to throw the powder up to the surface before solution can take place, it is evidently most convenient to divide the arsenic, by previous solution in marine acid, in order that the nitrous acid may with facility act upon all its parts. This appears to be the use of the marine acid. The ignition at the end of the operation serves to drive off the adventitious acids which might remain together with that of arsenic; and from this circumstance it is seen how much more fixed the arsenical acid is than the calx itself. This acid, which appears to be scarcely, if at all, less poisonous than arsenic itself, has no taste when perfectly dry; which seems to arise from its not readily combining with water, though it is soluble in a small proportion of that fluid, and even attracts it from the atmosphere, and deliquesces in process of time. The glass retort is much corroded during this operation, and the acid, after solution in water, deposits an earth which is found to be siliceous. It is not clear, however, from this circumstance, that the dry arsenical acid dissolves siliceous earth, because the glass may, with equal probability, be supposed to suffer decomposition by virtue of a superior affinity between the alkali of the glass and itself.

The inventor likewise converted arsenic into an acid by means of manganese. This metallic calx is known to be capable of affording vital air during any process, by which it is brought nearer to the metallic state: it therefore produces, in many bodies to which it may be properly applied, changes similar to those effected by combustion; that is to say, according to the ancient theory, it dephlogisticates them. If one part of powdered manganese be mixed, in a tubulated retort, with three parts of the above described marine acid, the vessel being of such a size as that the mixture shall occupy one fourth of its capacity; and if one fourth of white powdered arsenic, with the addition of one eighth of distilled water, be put into a receiver, which is then to be luted on, and distillation be effected by a sand heat, the manganese will convert the marine acid into that aeriform fluid, which is known by the name of dephlogisticated marine acid. This acid will be absorbed by the water in the receiver, where it will produce an effect upon the arsenic, of the same nature as that which itself sustained in the retort from the manganese, that is to say, it will dephlogisticate it, or communicate that vital air which is necessary to convert it into an acid. During the course of some hours the arsenic will be dissolved, and two different liquid strata, which will not mix together, will be perceived in the re-

ceiver. This solution may now be put into a clean glass retort, and distilled to dryness by a fire which must be raised to ignition at the end of the process. In this operation, likewise, two different liquids pass over into the receiver, and do not unite together. A white mass remains in the retort, which is the acid of arsenic.

The two different liquids are stated by Scheele to consist of liquid butter of arsenic, and solution of arsenical acid: for the dephlogisticated, or aerated marine acid, which comes over in the operation with manganese, acidifies part of the arsenic in the receiver, and is itself by that means again converted into common marine acid, which dissolves a portion of the arsenic that yet remains unchanged. This last solution being much heavier than the other, occupies the lower place.

The arsenical acid was likewise obtained more than forty years ago, by the celebrated Macquer, who supposed it to be mere arsenic. Pelletier has repeated the process, by mixing white arsenic with the saline combination of nitrous acid and volatile alkali, and distilling the mixture. Fuming nitrous acid first passes over, and afterwards the volatile alkali, while the arsenic is left behind in the state of an acid.

The white calx of arsenic gains about one ninth of additional weight by being converted into an acid: this, however, must vary, if it should appear, upon experiment, that the calx of arsenic is not always accurately in the same state.

The acid of arsenic is again reduced by treatment with inflammable matter. If one ounce of dry acid of arsenic be exposed to a temperature nearly approaching to ignition, it flows into a clear liquid, which when cold is of a milky colour; but if the heat be raised to such a degree as to soften the glass retort, the acid begins to boil, and a sublimation of arsenical calx takes place, which continues as long as the ebullition is kept up. In the experiment of Scheele, the acid was lost by the melting of the retort at the end of half an hour: the same quantity of dry acid of arsenic was dissipated by heat in an open crucible in a quarter of an hour, probably because the heat was greater. The vapours received under a glass vessel consisted in the white calx of arsenic, and not the arsenical acid. A small quantity of clear glass, difficultly fusible, remained in the crucible, and was found to consist of clay and arsenical acid. In the humid way, the arsenical acid is not affected by digestion with charcoal; but if the mixture be put into a retort, and the moisture driven off by heat, which is afterwards to be increased until a low ignition is produced, the mass at this last period takes fire suddenly, the whole of the acid being reduced and sublimed into the neck of the retort. Most of this product consists of the regulus, or arsenic in the metallic state, the rest consisting of the white calx of arsenic with powder of charcoal, no doubt raised before the complete reduction had time to take place. No vestige of acid is found in this operation, but a few drops of water are found in the receiver, which must not be applied until the whole of the moisture of the original mixture has been dissipated. This experiment succeeds equally with the arsenical acid prepared by means of manganese. After some days digestion of the acid of arsenic with oil of turpentine, unctuous oil, and sugar, the mixture becomes thick and black; and if some marine acid be abstracted from this by a gentle heat, it is found to contain arsenic, or the white calx, as is proved by the addition of a small portion of nitrous acid, and distillation, according to the first process for obtaining the acid of arsenic. Spirit of wine is not changed either by digestion or distillation with the acid of arsenic. One part of sulphur digested with six of this acid suffers no change; but when the mixture is evaporated to dryness, and distilled in a glass retort with a receiver;

a sudden and almost instantaneous combination takes place at the heat which melts the sulphur. The whole mass rises at once in the form of a red sublimate, and a volatile sulphureous acid is found in the receiver.

The foregoing experiments may in general be explained upon the common principles of those reductions by which calcined or burned bodies have their state of combustibility restored; that is to say, by the transmission of the principle of inflammability, or phlogiston, from some other combustible body, or the extrication of vital air, which is either volatilized, or transferred from the reduced substance to that which is employed in the reduction. These theories correspond with the reduction of arsenical acid into the metallic state by heating it with charcoal; the phlogiston of the charcoal being either transferred to the arsenical acid, which it reduces at the same time that the charcoal becomes burned; or otherwise, the effect being produced simply by the transmission of vital air from the arsenical acid to the charcoal; or thirdly, by a mutual transfer of both these principles, according to such chemists as find sufficient reason to combine the theory of Stahl with that of the moderns. The first experiment, however, in which the arsenical acid is reduced by mere heat in a closed vessel, is not so easily explained according to the doctrine of phlogiston. The great discoverer of this acid, Scheele, retaining the doctrine that combustion is occasioned by the transmission of a principle of inflammability, was driven to the conclusion, from this fact, and others of the like nature, that mere heat contains that principle, and that, in the present instance, the arsenical acid becomes reduced by virtue of a decomposition of the matter of heat, one of whose principles, namely, phlogiston, was supposed to combine with and revive the arsenical acid. To those who consider the existence of a matter of heat as neither proved nor probable, and who even, if inclined to admit that existence, might still be disposed to doubt whether it were compounded, and of what parts, the explanation of Scheele will probably appear rash and embarrassed; and to such the explanation of the modern theory will be attended with peculiar felicity. In this theory, the arsenical acid being taken to consist of vital air united with the metal, arsenic is reduced simply by the expulsion of that vital air by heat; a phenomenon by no means singular, and which indeed only requires the test of experiment in the present instance, to constitute one of the strongest arguments in its favour.

In the last experiment with sulphur it appears that this substance is not disposed to combine with arsenic, unless it be considerably reduced. During this process, part of the sulphur is therefore burned, and converted into volatile vitriolic acid, either by the absorption of part of the vital air of the arsenic, or by the communication of a portion of its phlogiston.

Acid of arsenic, saturated with fixed vegetable alkali, by the test of the solution of lacmus, produces a neutral deliquescent salt, which cannot be reduced to crystals: but if as much acid be added as shall enable the solution to reddens lacmus, and produce no change upon syrup of violets, the solution will afford fine crystals. When this salt was urged by a strong heat for an hour, in a crucible upon which another was luted, and the whole was suffered to grow cold, the inside of the crucible was found covered with a white glazing, but the remaining salt, when examined by solution and crystallization, was found to possess the same excess of acid as before. This crystallized salt being exposed to a red heat in a crucible, with one eighth of its weight of charcoal powder, boiled violently, and a very fine regulus of arsenic was sublimed: the residue was alkaline, and exhibited no trace of the arsenical acid.

The mineral alkali, when perfectly saturated with arsenical acid, forms a crystallizable salt resembling that last mentioned. If an excess of acid be added, the salt proves deliquescent, and does not crystallize.

Volatile alkali, saturated with the arsenical acid, affords a salt in crystals resembling the foregoing: it loses its transparency by heat, which dissipates the volatile alkali. This salt comes over in the fluid state, after which the residue melts, and arsenic is sublimed: a white mass remains, which likewise melts in a stronger heat, and proves to be the acid of arsenic. During this process a disengagement of that peculiar fluid, which is known by the name of phlogisticated air, takes place just as the arsenic is sublimed. It appears, therefore, that the first heat disengages part of the volatile alkali; but that the last portion of the volatile alkali adheres so strongly to the acid of arsenic, as to remain until the heat has become sufficient to decompose it into its component parts, which, from other experiments, are known to be inflammable air and phlogisticated air. The phlogisticated air flies off, while the inflammable air affords phlogiston to a portion of the acid, which then sublimes in the form of the white calx; or otherwise, according to the antiphlogistic theory, the inflammable air unites with a portion of the vital air of the arsenic, which thus becomes reduced. The conjunction of these two airs is said to form water, though Dr. Priestley has rendered that position somewhat doubtful. See VOLATILE ALKALI; and also WATER.

The acid of arsenic does not take the alkali either from vitriolated tartar or Glauber's salt, in the humid way; in the dry way it decomposes both, but the former requires a stronger heat than the latter. One part of purified nitre being distilled with three parts of acid of arsenic, the humidity of the mass passed over first, after which followed nitrous acid; the residue contained the neutral arsenical salt of Macquer, and some undecomposed nitre. Common salt, distilled with three times its weight of arsenical acid, was in part decomposed: a portion of marine acid passed over into the receiver, and the residue consisted of common salt and marine alkali supersaturated with acid of arsenic. One part of sal-ammoniac was distilled with three parts of acid of arsenic: marine acid with water first came over; this was followed by a more concentrated marine acid, at the same time that the remaining mass entered into fusion. Immediately afterwards a white smoke filled the retort, a white powder was sublimed, a pungent volatile alkali passed over into the receiver, and a residuum of arsenical acid was left in the retort: the white powder which arose proved, upon examination, to consist of sal-ammoniac, with a portion of calx of arsenic. Upon a repetition of the experiment, with a bladder applied instead of a receiver, it was found that phlogisticated air was extricated at the time the sublimate rose: from which circumstance it follows, that part of the acid of arsenic first combined with part of the volatile alkali of the sal-ammoniac, and caused the disengagement of marine acid; that when the heat was increased, the sal-ammoniac was sublimed, and soon afterwards the volatile alkali, and a portion of phlogisticated air from that part of the volatile alkali which afforded inflammable air to revive the arsenic, which was driven up nearly at the same time. The theories of the revivification of the arsenic have already been sufficiently insisted on.

Gypsum, or selenite, mixed with two parts of dry acid of arsenic, gave out vitriolic acid by a red heat, and the remainder fused into an opaque milky glass. Ponderous spar, or the combination of vitriolic acid and ponderous earth, produced nearly the same appearances, though with a stronger heat. Twelve parts of acid of arsenic are required to decompose one of fluor spar. The sparry acid comes over together with
siliceous

siliceous earth, which it takes from the glass, and deposits as it comes in contact with water placed for that purpose in the receiver.

When acid of arsenic is dropped into lime-water, it forms a combination with that earth which falls down, but is again dissolved if more acid be added. This solution affords small crystals by evaporation. The vitriolic acid takes the lime from a solution of these salts. The precipitate of lime, combined with the acid of arsenic, forms a thick flux after strong calcination for an hour in a covered crucible, but it still retains the acid. When equal measures of this calcareous salt and charcoal powder are exposed to strong heat in a retort, a shining regulus is sublimed, and the residue consists of quicklime mixed with charcoal and some arsenic.

Magnesia is soluble in the arsenical acid, but coagulates near the point of saturation. If the fluid be evaporated when the quantity of magnesia is not sufficient to form the coagulum, it grows gelatinous, and the gelatinous part does not afford crystals by solution in water and evaporation. The phenomena of this magnesian salt, in the dry way, with charcoal, nearly resembles those of lime in similar circumstances.

Pure clay, or the earth which is precipitated by vegetable alkali from a solution of alum, is easily soluble in the acid of arsenic, but coagulates as soon as it arrives at the point of saturation: its acid is not driven off by mere heat. If the solution of this neutral salt be evaporated to dryness, and then mixed with a little charcoal powder, and exposed to distillation with a strong heat, a small quantity of yellow sublimate rises into the neck of the retort, and likewise some shining regulus, at the same time that volatile sulphureous acid passes over into the receiver: the residuum does not appear to be pure clay, for it is difficultly soluble in vitriolic acid, with which, however, it forms some alum in the space of two months. The acid of arsenic acts very sparingly upon common white clay in the humid way, but these substances unite in a strong red heat.

The precipitation afforded by adding vitriolic acid to the liquor of flints was not at all acted upon by the acid of arsenic, either in the humid or dry way.

Ponderous earth is readily dissolved in the acid of arsenic, but the combination precipitates as soon as it has arrived at its point of saturation. This salt exhibits the same appearances in the dry way as the combinations of arsenical acid and lime.

The acid of arsenic being applied to the filings of the metals, in a long-necked flask, to prevent its reduction, acts upon several of them in a digesting heat. Gold and platina are scarcely acted upon. Silver is not attacked by digestion; but when the acid comes to be fused, the metal is dissolved, and affords a colourless glass, which is nearly transparent; soluble in water, with the loss of greatest part of the silver, which subsides in the form of a brown powder, containing a minute portion of the acid, and reducible, like the other precipitates of silver, by mere heat. Mercury is not attacked by the arsenical acid, in the heat of digestion; but when the acid and mercury are urged in a retort, by an heat which is near melting the vessel, part of the mercury combines with the acid, and forms a yellowish mass of extremely difficult fusion, very fixed, and soluble in water. Diluted nitrous and vitriolic acids have scarcely any effect on it, but marine acid readily dissolves it. This solution, by evaporation to dryness, and distillation, affords corrosive sublimate, and the residue is arsenical acid: whence it follows, that the mercury in the arsenical combination must have been perfectly calcined. Copper is dissolved by the arsenical acid in digestion, and affords a green solution. One part of copper filings, mixed with two of dry arsenical acid, affords a blue mass

mass by fusion, at an elevated degree of heat, which is soluble in water; and then proves to be the same combination as was produced by digestion. The watery solution lets fall a light blue powdery matter, consisting of a combination of copper with arsenical acid. Iron likewise is attacked by this acid during digestion, and the whole solution at last grows gelatinous, if the digestion be performed in an open vessel. If the digestion be performed in a long-necked or close vessel, it does not become gelatinous, but will afterwards become so if exposed to the air. In the dry way, when one part of iron filings is distilled with four of acid of arsenic, the mass makes a great effervescence towards the end; and, when it becomes dry, it takes fire upon increasing the heat; arsenic and regulus of arsenic being sublimed, and a black friable residuum being left at the bottom, which contains but little acid of arsenic. In this process it appears, that the iron, which is a metal very much exposed to combustion or calcination, suddenly deprives the arsenical acid of its vital air, and reduces it to the state of calx and regulus; at the same time that, according to the ancient hypothesis, phlogiston passes from the metal to the acid. Little effect is produced upon lead by digestion with the arsenical acid; but the combination takes place by fusion in the dry way, which affords a semi-opaque glass. When this is boiled in distilled water, the lead falls down in the form of a white powder, containing arsenical acid, but which does not afford arsenic by heat, unless charcoal be added. Tin, digested with arsenical acid, grows black at first; afterwards becomes covered with a white powder, and at last the whole mass becomes gelatinous. In the dry way, one part of tin filings with two of the acid, heated in a retort, took fire when ignited; and the calx and regulus of arsenic immediately sublimed, leaving a limpid solution of tin, which, when cooled, was of a milky colour: this, when dissolved in distilled water, deposited a white calx, which contained very little acid of arsenic.

Zinc is the only metallic substance which effervesces when digested with the arsenical acid. The zinc grows black, and the transparency of the acid is destroyed by a quantity of black powder, which, on examination, by burning on a red hot iron, proves to be regulus of arsenic. This precipitated regulus soon defends the zinc from further solution. The air which escapes during the effervescence is inflammable, holding regulus of arsenic in solution, which it deposits on burning. Either of the chemical theories will serve to explain these effects, for the zinc is calcined by receiving the vital air of the acid, while it is supposed to give out phlogiston enough to reduce the acid basis to a regulus, and to afford the inflammable air which escapes: or, in the other theory, it will be said, that the zinc, having a strong tendency to combine with vital air, and become calcined, cannot decompose water at a moderate temperature, unless an acid be present, to remove the coating of a calx by solution as fast as it is formed, which mere water cannot do. This, therefore, is the first consequence of the mutual action of water, zinc, and the acid; namely, vital air quits the water to unite with the zinc, and inflammable air flies off at the same time that the acid combines with the calx of zinc. But of the two metallic bases, which are here combined by the intermedium of vital air, the zinc has a strong tendency to calcination, and the arsenic to become revived: it appears, therefore, from the facts, that the zinc, attracting the vital air more strongly, becomes still more calcined, and consequently less soluble; while the arsenic is reduced by the loss of its vital air. Whence it must follow, that the metallic zinc which remains, being enveloped with calx of zinc and metallic arsenic, can no longer be acted on by the acid and water, which still continue undecomposed. On this, and similar occasions, it cannot, however, be too often repeated to the chemical student, that

that theories ought to be cautiously followed, as of use in the arrangement of facts, and in directing the path to future investigations; that discriminating phenomena ought to be earnestly sought after, because of infinitely more value than the most ingenious speculations; and that an attachment to system, though it frequently gives life and energy to the exertions of genius, is in general a certain source of prejudices, which disable the enquirer from pursuing the search after truth, and fix his mind upon words instead of things.

In the dry way, when one part of the filings of zinc was mixed with two of the arsenical acid, and distilled, the mass took fire, with a very bright inflammation, as soon as the retort became red hot: the vessel was burst by the explosion; and in its neck were found regulus of arsenic, and flowers of zinc. This effect may be explained from the same considerations as were applied to the combustion, which takes place in like circumstances with iron.

Bismuth is acted upon by the arsenical acid, in digestion. Water precipitates a powder from the solution, which consists of acid of arsenic combined with calx of bismuth. In the dry way, bismuth is calcined by this acid, but not dissolved, a little arsenic being sublimed; and if water be added to the cooled mass, the acid is taken up, but the calx remains. Regulus of antimony is affected nearly in the same manner as bismuth, in the humid way; but, in the dry way, an inflammation takes place at the time of fusion. By digestion with cobalt, the acid of arsenic assumed a rose-colour; but much of the cobalt remained undissolved. The whole mass being distilled to dryness, and fused, afforded glass of a violet colour and semi-transparent. Nickel communicates a green colour to this acid by digestion; a quantity of green powder, mixed with arsenic, being precipitated: the arsenic may be separated by a gentle heat. In the dry way, the acid combines with nickel, and forms a yellow mass with grey streaks upon it, resembling a vegetation. By boiling in water, the acid is taken up, and a yellow powder left behind, consisting of a combination of nickel and arsenic, most probably in the acid state: the arsenic is reduced with charcoal, but the nickel is not. Calx of manganese is scarcely acted upon by acid of arsenic; but, when the manganese is partly or entirely reduced, it is dissolved in the humid way, and affords crystals as soon as the acid is nearly saturated. The regulus of arsenic, digested with the arsenical acid, becomes covered with a white powder of arsenical calx. When one part of the regulus was mixed with two parts of the dry acid, and exposed to distillation, the regulus was sublimed before the heat was sufficiently great to fuse the acid, and consequently no mutual action took place; but when the acid was first fused, and the regulus added successively in small lumps, inflammation took place, and calx of arsenic was sublimed.

ACID OF BENZOIN. This acid, which is commonly known by the name of flowers of benzoin, or benjamin, is obtained by sublimation from that resinous substance. The operation is easily made, and affords a very elegant and pleasing example of this chemical process. For this purpose a thin stratum of powdered benzoin is spread over the bottom of a glazed earthen pot, to which a tall conical paper covering is fitted: a gentle heat is then to be applied to the bottom of the pot, which fuses the benzoin, and fills the apartment with a fragrant smell, arising from a portion of essential oil and acid of benzoin which are dissipated into the air; at the same time the acid itself rises very suddenly in the paper head, which may be occasionally inspected at the top, though with some little care, because the fumes will excite coughing. This saline sublimate is condensed in the form of long needles, or frail filaments of a white colour, crossing each other in all directions.

tions. When the salt ceases to rise, the cover may be changed, a new one applied, and the heat raised: more flowers of a yellowish colour will then rise, which require a second sublimation to deprive them of the empyreumatic oil they contain.

The sublimation of the flowers of benzoin may be conveniently performed by substituting an inverted earthen pan instead of the paper cone. In this case the two pans should be made to fit, by grinding on a stone with sand, and they must be luted together with paper dipped in paste. This method seems preferable to the other, where the presence of the operator is required elsewhere. The heat applied must be very gentle, and the vessels ought not to be separated till they have become cool.

The quantity of flowers or acid obtained in these methods differs according to the management, and probably also from difference of purity, and in other respects of the resin itself. It usually amounts to no more than about one eighth part of the whole weight. The whole acid of benzoin is obtained with greater certainty in the humid process of Scheele: this consists in boiling the powdered resin with lime-water, and afterwards separating the lime by the addition of marine acid. Twelve ounces of water are to be poured upon four ounces of flaked lime; and, after the ebullition is over, eight pounds, or ninety-six ounces, more of water are to be added: a pound of finely-powdered benzoin being then put into a tin vessel, six ounces of the lime-water are to be added, and mixed well with the powder; and afterwards the whole of the lime-water in the same gradual manner, because the benzoin would coagulate into a mass, if the whole were added at once. This mixture must be gently boiled for half an hour with constant agitation, and afterwards suffered to cool and subside during an hour. The supernatant liquor must be decanted, and the residuum boiled with eight pounds more of lime-water; after which the same process is to be once more repeated: the remaining powder must be edulcorated on the filter by affusions of hot water. Lastly, all the decoctions, being mixed together, must be evaporated to two pounds, and strained into a glass vessel.

This fluid consists of the acid of benzoin combined with lime. After it is become cold, a quantity of marine acid must be added, with constant stirring, until the fluid tastes a little sourish. During this time the last-mentioned acid unites with the lime, and forms a soluble salt, which remains suspended, while the less soluble acid of benzoin, being disengaged, falls to the bottom in powder. By repeated affusions of cold water upon the filter, it may be deprived of the marine salt and acid with which it may be mixed. If it be required to have a shining appearance, it may be dissolved in a small quantity of boiling water, from which it will separate in silky filaments by cooling.

The acid of benzoin is so inflammable that it burns with a clear yellow flame without the assistance of a wick. The sublimed flowers in their purest state, as white as ordinary writing-paper, were fused into a clear transparent yellowish fluid, at the two hundred and thirtieth degree of Fahrenheit's thermometer, and at the same time began to rise in sublimation. It is probable that a heat somewhat greater than this may be required to separate it from the resin. It is strongly disposed to take the crystalline form in cooling. The concentrated acids of vitrol and of nitre dissolve this concrete acid, and it is again separated, without alteration, by adding water. Other acids dissolve it by the assistance of heat, from which it separates by cooling, unchanged. It is plentifully soluble in ardent spirit, from which it may likewise be separated by diluting the spirit with water. It readily dissolves in oils, and in melted tallow. If it be added in a small proportion to this last fluid, part
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of the tallow congeals before the rest, in the form of white opaque clouds. If the quantity of acid be more considerable, it separates in part by cooling, in the form of needles or feathers. It did not communicate any considerable degree of hardness to the tallow, which was the object of this experiment. When the tallow was heated nearly to ebullition, it emitted fumes which affected the respiration, like those of the acid of benzoïn, but did not possess the peculiar and agreeable smell of that substance. A stratum of this tallow, about $\frac{1}{20}$ of an inch thick, was fused upon a plate of brass, together with other fat substances, with a view to determine its relative disposition to acquire and retain the solid state. After it had cooled it was left upon the plate, and in the course of some weeks it gradually became tinged throughout of a blueish green colour. If this circumstance be not supposed to have arisen from a solution of the copper during the fusion, it seems a remarkable instance of the mutual action of two bodies in the solid state, contrary to that axiom of chemistry which affirms, that bodies do not act on each other, unless one or more of them be in the fluid state.

This acid reddens litmus, but scarcely affects syrup of violets: it forms neutral salts with the alkalis, which are very soluble in water, and decomposable by the mineral acids. With the vegetable alkali it forms a crystallizable deliquescent salt: with mineral alkali it affords efflorescent crystals, and with the volatile alkali it forms a deliquescent salt, not easily brought to crystallize. These salts are soluble in oils.

This acid forms a crystallizable salt with calcareous earth, which is not easily soluble in water, and has a sweetish taste without any pungency. With magnesia it forms small feathery crystals, of a sharp bitter taste, and easily soluble in water; and with alum it forms an astringent salt.

The solubility of the acid of benzoïn in nitrous and other acids, and its subsequent separation, indicate that its principles are not easily separable from each other. Attempts have been made to decompose it by repeated abstractions of nitrous acid: the nitrous acid rises first, scarcely altered, except towards the end, when it becomes fuming, and the acid of benzoïn is afterwards sublimed with little alteration. By repeating the process, however, the acid of benzoïn is said to become more fixed, and at length to afford a few drops of an acid, resembling the acid of sugar in its properties.

This acid has been obtained in small quantities from balsam of Peru, from storax, and from the saponaceous extract of urine, which last substance afforded it by repeated abstraction of the nitrous acid.

ACID OF BORAX, or SEDATIVE SALT. This acid has been found uncombined in the waters in certain lakes in Tuscany and elsewhere; but it is most abundantly obtained from borax, which is a salt consisting of this acid united with mineral alkali. (See BORAX). This combination is not destroyed by exposing the salt to a moderate degree of heat. The addition of some stronger acid is necessary to combine with the alkali. If martial vitriol be mixed with borax, and both be dissolved in water, and evaporated till a pellicle appears, the liquor may then be put into a small glass alembic: upon the application of heat the water first arises, and afterwards the sedative salt, or acid of borax. In this process the vitriolic acid of the martial vitriol quits its iron to unite with the alkali of the borax, at the same time that the acid of the borax in all probability combines with the iron: this last combination, however, is destroyed by the heat, and the acid of borax sublimes alone. Mere vitriolic acid, or any other acid whose affinity with the alkali at the

temperature of sublimation is stronger than that of the acid of borax, might be used with equal advantage in this decomposition.

The acid of borax is most commonly, however, obtained in the humid way: for this purpose the vitriolic acid may be added to a saturated solution of borax in boiling water, in such a proportion as that there may be a perceptible excess of acid; and the sedative salt will be disengaged in white scales as the water cools. These must be rinsed in a small quantity of very cold water.

The acid of borax requires about fifty times its weight of cold water for its solution, but much less when the water is boiling. In a moderate heat this concrete acid melts with less intumescence than borax itself, and runs into a clear glass, which is not volatile unless water be present. This glass does not differ from the original acid, except in having lost its water of crystallization. If it be again dissolved in water, it may be crystallized or sublimed as before. It is soluble in spirit of wine, and communicates a green colour to the flame of that inflammable fluid: oils likewise dissolve it by the assistance of heat. In the dry way it dissolves earths, more particularly the siliceous earth.

The acid of borax retains its form in the air, but is somewhat disposed to attract moisture: it affords no precipitate upon the addition of Prussian alkali to its solution.

With vegetable alkali it forms a borax similar to that of commerce: with mineral alkali it forms common borax, provided the alkali be in excess; and with volatile alkali it forms a crystallizable salt. Magnesia forms a compound with it which is decomposable by all other acids, and by spirit of salt. Calcareous earth forms a salt of difficult solution. Argillaceous earth, in the humid way, forms a substance of difficult solution; and, by fusion, in the dry way, with half its weight of sedative salt, it affords a hard mass resembling pumice-stone, part of which is soluble in water. The phenomena with siliceous earth are nearly the same in a crucible; but the fusion may be more completely effected by the blow-pipe. The action of the acid of borax upon gold is scarcely perceptible, either in the wet or dry way. It does not act at all upon platina, nor precipitate it from aqua regia. No direct action takes place between this salt and mercury, but it precipitates that metal from its solution in nitrous acid. A slight action takes place between this acid and copper in the direct way, and the solution of borax precipitates all the solutions of copper in acids. Lead is scarcely, if at all, acted on by sedative salt, but it is thrown down in combination with it from the vitriolic, nitrous, marine, or acetous acids. One part of sedative salt is said to form, by fusion with two parts its weight of minium, a fine, clear, hard, and insoluble glass, of a greenish yellow colour. This acid has very little effect upon tin, with which, however, it may be brought to combine by long trituration and digestion with water. The slag formed by melting equal parts of sedative salt and tin filings, afforded the same salt by solution in water. Iron is sparingly soluble in acid of borax, and affords yellow crystals. A similar solution may also be produced by fusion and lixiviation. Regulus of antimony is not directly attacked, but its solution in aqua regia is precipitated by borax. Bismuth, likewise, is not acted on, but is precipitated by borax from its solution in a mixture of vitriolic and marine acid. A slight action between this salt and zinc is produced by digestion, and the fluid by evaporation affords a saline mass. The flowers of zinc melt with sedative salt into a light green insoluble slag. Calx of arsenic unites with this salt either in the humid or dry way, and forms a soluble and crystallizable compound. Regulus

of cobalt, and also nickel, are not directly acted on, but they are precipitated by it from their respective solutions.

ACID OF CITRONS, or LEMONS. The juice of lemons, or limes, has all the characters of an acid of considerable strength: on account of the mucilaginous matter with which it is mixed in its first state, it is very soon altered by spontaneous decomposition. Various methods have been contrived to prevent this effect from taking place, in order that this wholesome and agreeable acid might be preserved for use in long voyages, or other domestic occasions. The juice may be kept in bottles under a thin stratum of oil, which indeed prevents, or greatly retards its total decomposition; though the original fresh taste soon gives place to one which is much less grateful. In the East Indies it is evaporated to the consistence of a thick extract. If this operation be carefully performed by a very gentle heat, it is found to be very effectual. When the juice is thus heated the mucilage thickens, and separates in the form of flocks, part of which subsides, and part rises to the surface: these must be taken out. The vapours which arise are not acid. If the evaporation be not carried so far as to deprive the liquid of its fluidity, it may be long preserved in well closed bottles; in which, after some weeks standing, a farther portion of mucilage is separated, without any perceptible change in the acid.

Of all the methods of preserving lemon-juice, that of concentrating it by frost appears to be the best, though in the warmer climates it cannot conveniently be practised. Lemon-juice, exposed to the air, in a temperature of between 50° and 60° , deposits in a few hours a white semi-transparent mucilaginous matter, which leaves the fluid, after decantation and filtration, much less alterable than before. This mucilage is not of a gummy nature, but resembles the gluten of wheat in its properties: it is not soluble in water when dried. More mucilage is separated from lemon-juice by standing in closed vessels. If this depurated lemon-juice be exposed to a degree of cold of about seven or eight degrees below the freezing point, the aqueous part will freeze, and the ice may be taken away as it forms; and if the process be continued until the ice begins to exhibit signs of acidity, the remaining acid will be found to be reduced to about one eighth of its original quantity, at the same time that its acidity will be eight times as intense, as is proved by its requiring eight times the quantity of alkali to saturate an equal portion of it. This concentrated acid may be kept for use, or, if preferred, it may be made into a dry lemonade, by adding six times its weight of fine loaf sugar in powder.

The above processes may be used when the acid of lemons is wanted for domestic purposes, because they leave it in possession of the oils, or other principles, on which its flavour peculiarly depends; but in chemical researches, where the acid itself is required to be had in the utmost purity, a more elaborate process must be used. Boiling lemon-juice is to be saturated with powdered chalk, whose weight is to be noted. The neutral saline compound is scarcely more soluble in water than selenite; it therefore falls to the bottom, while the mucilage remains suspended in the watery fluid, which must be decanted off: the remaining precipitate must then be washed with warm water until it comes off clear. To the powder thus edulcorated, a quantity of vitriolic acid, sufficient to saturate the chalk, and diluted with ten parts of water, must be added, and the mixture boiled a few minutes. The vitriolic acid combines with the lime, and forms selenite, which remains behind when the cold liquor is filtered, while the disengaged acid of lemons remains dissolved in the fluid. This last must be evaporated to the consistence of a thin syrup, and vitriolic acid must be then added in small portions, to precipitate the

lime, if any should still remain in combination with acid of lemons. When no more precipitate is afforded by the addition of vitriolic acid, a farther evaporation separates the pure acid of lemons in crystals. It is necessary that the vitriolic acid last added should be rather in excess, because the presence of a small quantity of lime will prevent the crystallization. This excess will be found in the mother water.

The crude acid of lemons forms crystallizable salts with the mineral and the volatile alkalis; but its combination with the vegetable alkali does not crystallize. The pure acid affords uncrystallizable and deliquescent salts with the fixed alkalis, and with volatile alkali a salt which yields its alkali in distillation. With calcareous, argillaceous, and ponderous earths, it forms salts of difficult solubility; but with magnesia a very soluble saline mass resembling gum. Its action on metallic bodies is not considerable, though it dissolves iron and zinc, and during the solution affords inflammable air.

By repeated abstraction of the nitrous acid from the acid of lemons it becomes converted into acid of sugar. In this process, as well as in others of the same nature, it is necessary that the quantity of nitrous acid should not be too considerable, lest its action should convert the acid of sugar into vinegar and fixed air. Two hundred grains of nitrous acid being abstracted from sixty grains of the acid of citrons, afforded thirty grains of acid of sugar.

ACID OF FAT. The fat of animals is a substance nearly of the same nature as those oils called fat oils in the vegetable kingdom: it affords an acid by distillation, which may be rendered purer by rectifying. Saturation with a fixed alkali, and subsequent distillation with vitriolic acid, render it still purer, though contaminated with sulphureous acid, unless the neutral salt has been previously kept in fusion until all its oily particles are destroyed. If this acid be supposed to contain any portion of the vitriolic, it may again be rectified from some of the neutral salt.

The acid of fat may be obtained also from the solution of soap, formed with pure vegetable alkali and tallow: for this purpose the soap is to be boiled with water to the consistence of a jelly. The tallow rises to the top upon the addition of alum: the saline substance remaining in the water then consists of vitriolated tartar, alum without the usual quantity of acid, and a combination of the acid of fat with the vegetable alkali. By the addition of vitriolic acid to this saline mass, the acid of fat may be obtained by distillation. But the most elegant method of obtaining this acid consists in mixing a quantity of melted suet with quicklime, suffering the mixture to cool, and afterwards boiling it with a large quantity of water. After filtration and evaporation the calcareous salt, formed by the combination of the acid of fat with the earth, is obtained of a brown colour. A slight calcination renders it purer by the destruction of a portion of inflammable matter; and by solution, filtration, and the addition of a certain quantity of fixed air, to precipitate the superfluous lime, a clear solution of the acid of fat, neutralized with calcareous earth, is obtained. Evaporation of the fluid affords the pure white salt; and this, when distilled, with the addition of vitriolic acid, affords the acid of fat, which comes over into the receiver, while the lime and vitriolic acid remain in the retort in the form of selenite.

The acid of fat is liquid, fuming, and of a penetrating odour; decomposable with heat, which turns it yellow, and extricates or produces fixed air. Blue colours are strongly reddened by it: water dissolves it in all proportions. With lime, and also with the fixed alkalis, it forms crystallizable salts, which are not decomposed in a moderate

moderate heat. With magnesia it forms an uncrystallizable saline mass, which may be reduced to a gummy consistence. With clay, or pure argillaceous earth, it unites with difficulty, forming an astringent uncrystallizable mass. Siliceous earth is thought to be corroded by this acid, probably from its action on glass, in which it may act on the alkali and not on the earth, for it has no action upon siliceous earth precipitated from liquor of flints. It acts on a number of the metals. Gold and platina are not acted on; but it dissolves the precipitates, which are thrown down from their acid solutions, by the addition of fixed alkalis. The acid of fat is, however, rendered capable of dissolving gold by abstraction from manganese. A very small portion of silver is dissolved by the acid of fat; and it takes silver and mercury from their solutions in nitrous acid, forming combinations which fall to the bottom. Mercury is not directly acted upon, unless the acid be repeatedly abstracted from it. This process changes the mercury into silver-coloured plates, which are soluble in the acid that comes over, not decomposable by common salt, but depositing their quicksilver upon copper.

The acid of fat affords a white precipitate, with a solution of corrosive sublimate. This is considered as a characteristic mark for distinguishing the acid.

Copper is dissolved by the assistance of heat in the acid of fat, with which it forms a deliquescent crystallizable mass. Iron likewise affords deliquescent crystals. Lead is corroded by it, and a considerable quantity of minium is dissolved. Filings of tin are corroded by the sebaceous acid into a yellow powder, especially by the assistance of heat, and at the same time emit a very foetid smell. The liquor, notwithstanding filtration, continues turbid, deposits in time a yellow powder, and acquires a fine rose-red colour. By adding water to the yellow powder obtained by the corrosion, a white deliquescent salt may be formed; and a similar salt may be obtained by dissolving a yellow powder, which is precipitated by this acid from a solution of tin in aqua regis.

Regulus of antimony is soluble in the acid of fat by the assistance of heat, and forms a salt in permanent crystals. Zinc is easily and plentifully dissolved. Bismuth is not dissolved in its metallic state, but it precipitates this metal from its solutions in nitrous acid, and re-dissolves the precipitate of bismuth made by adding fixed alkali to that solution. The regulus of cobalt, or of nickel, are not dissolved by this acid, neither does it afford a precipitate from their solutions in nitrous acid, but it dissolves their precipitates obtained by the addition of alkali. White arsenic is copiously dissolved in a gentle heat, and affords small crystals. Manganese is likewise plentifully taken up, and affords a clear solution.

The acid of fat produces an ether by distillation in the usual method with spirit of wine: it expels the acid from nitre, common salt, foliated earth, and Glauber's salt, by distillation. The acid of the last-mentioned salt comes over in the sulphureous state. It likewise precipitates the acid of tartar from a solution of soluble tartar, or vegetable alkali saturated with tartareous acid.

The acid of fat has not yet been decomposed. When nitrous acid is abstracted from tallow, there is a production of acid of sugar, and not the sebaceous acid. Hence it has been concluded, that this acid is nearly of the same nature as the other acids obtained from organized substances.

ACID OF FLUOR, or FUSIBLE SPAR. The fusible spar, which is generally distinguished by the name of Derbyshire spar, consists of calcareous earth in combination with the acid at present under our consideration. If the pure fluor, or spar, be placed in a retort of lead, with a receiver of the same metal adapted, and half its weight of vitriolic acid be then poured upon it, the acid of spar will be dis-

disengaged in the aerial form by the application of a moderate heat. This acid air readily combines with water; for which purpose it is necessary that the receiver should previously be half filled with that fluid. When experiments are required to be made with the acid in the elastic state it must be received over mercury.

The distinguishing and most remarkable property of this acid is its power of combining with and volatilizing siliceous earth, which remains suspended with it in the permanently elastic form. The first experiments with fluor spar were made in glass vessels, and were attended with the singular phenomenon of an earthy matter being deposited at the instant that the acid air came in contact with the water in the recipient. Upon examination it was found to consist of siliceous earth; and subsequent experiments proved that it was obtained by corrosion of the glass retort, and deposited in consequence of the acid possessing a less power of suspending siliceous earth when combined with water, than when in the elastic state.

The acid of fluor unites with argillaceous earth, and forms a neutral salt of a gelatinous adhesive consistence. Calcareous earth re-produces the fusible spar. With ponderous earth it affords a salt of very difficult solution, which effloresces in the air: it readily combines with magnesia, and forms a salt scarcely soluble in water, unless the acid be in excess, in which case the salt may be obtained in slender crystals by evaporation. These crystals are not decomposed by the heat of distillation, and not soluble in water, though in some measure in spirit of wine. None of the acids decompose this salt. The fluor acid takes magnesia from every other acid.

Siliceous earth being dissolved by Bergman in diluted acid of spar, afforded, in the course of two years standing, transparent crystals resembling quartz, but not so hard. This acid has been successfully used to make etchings upon glass, in the same manner as nitrous acid has long since been applied to copper. Whether this art can ever be applied to the multiplying of copies must be determined by future researches.

The acid of fluor unites with fixed alkalis, and forms salts of a gelatinous consistence, which do not crystallize, but take a foliated form by evaporation. The combination of this acid and volatile alkali deposits a gelatinous sediment, and affords crystals, which are partly decomposed by sublimation, and attract moisture from the air.

Gold, in its metallic state, is not dissolved by the fluor acid; but its precipitate, obtained by adding an alkali to the solution in aqua regia, is soluble. The action of this acid on platina is not known. Silver resists its solvent power; but the precipitate thrown down by an alkali is soluble in part, and part remains undissolved. It throws down a precipitate from the nitrous solution of silver. Calx of lead is soluble in this acid. A powdery combination of the acid and the metal falls down when the solution is evaporated. Iron is powerfully attacked by the sparry acid, at the same time that inflammable air is extricated. The solution does not crystallize, but is converted into a hard mass by evaporation. Copper is attacked by this acid in its metallic state, but much more easily when calcined: the solution affords blue crystals. Crude mercury is not attacked, but the acid unites with the calx of that metal obtained by means of alkali. Part of this compound remains in solution, and part falls down in a powder, which melts before the blow-pipe into a yellow glass, most of which evaporates during the continuance of the heat, and leaves a small vitreous globule behind. The solution of mercury in nitrous acid is precipitated into a similar powder by the addition of the acid of fluor. Tin is not attacked, but its calx is dissolved by the fluor acid. Antimony and its regulus are not acted on.

Bismuth

Bismuth is affected nearly in the same manner as lead, and zinc in this respect is similar to iron. Regulus of cobalt is not dissolved, but it affords a yellow gelatinous solution with the calx of cobalt, and green crystals with the calx of nickel. It unites with arsenic, affording small crystals; and with manganese, by pouring a solution of the volatile alkaline salt of fluor acid into a solution of manganese in any of the mineral acids.

The natural disposition to refer our scientific acquisitions to those before known, has, as usual, induced several chemists to insist that the fluor acid is nothing but a modification of some other acid, more especially the acid of sea salt. Every experiment, however, hitherto made, tends to refute that conjecture; and the acid of spar appears to be as justly entitled to a separate class, in the present state of our knowledge, as any acid we are acquainted with. No experiments have yet been made which tend to shew the component parts of this acid substance. It is therefore only in the way of conjecture, or general inference, that, like the vitriolic, the nitrous, and other acids, in which the art of chemistry has been more successful, it is said to consist of a combustible base united with vital air, according to the usual mode of combination, whether the theory of the philogistian philosophers be admitted, or that of their opponents.

ACID OF GALLS, or THE ASTRINGENT PRINCIPLE. Many vegetable substances, such as the husks of nuts, the bark of the oak, the nutgall, and other bodies of the same nature, abound with a substance which has been distinguished by the name of the astringent principle. The nutgall is most plentifully used in dying processes, and the other purposes wherein the property of producing a black colour with solutions of iron is required; and as this matter resembles acids in its properties, it has been called the acid of galls.

The acid of galls is obtained by macerating the nutgall in water. This infusion reddens turnsole and blue paper. The acid is soluble in oils, ardent spirit, and ether. Acids dissolve it without impairing its property of forming a black precipitate with the solutions of iron: the distilled products of nutgalls likewise possess the same property. It decomposes metallic solutions, and combines with their calces. Gold and silver are precipitated by it in the metallic state. It acts upon and dissolves iron directly.

To obtain the acid of nutgalls in a crystallized form, one pound of the powder of galls must be added to six pounds of distilled water, and left to digest for a fortnight, at the temperature of between 70 and 80 degrees; after which the fluid must be filtered, and left to evaporate spontaneously in the open air, in a stone ware or glass vessel. The fluid becomes mouldy, and covered with a thick glutinous pellicle; abundance of glutinous flocks fall down; and in the course of two or three months the sides of the vessel appear covered with small yellowish crystals, which are likewise very abundant at the under surface of the pellicle which covers the liquor. The fluid must then be decanted; and ardent spirit being poured upon the mucilaginous deposition, the crystals and the pellicle, dissolves the salt by the assistance of heat, without touching the mucilage; and, by evaporation of this spirituous solution, the pure gallic acid is obtained in small brilliant crystals, of a grey colour inclined to yellow.

This acid, on account of its long exposure to the air, may consist either of a principle existing in the galls, or of that principle converted into an acid. It has the following properties: it precipitates martial vitriol, and other salts of iron, of a beautiful black colour, and strongly reddens the tincture of turnsole: when heated with contact of air, it swells up and burns, leaving a coal behind of difficult incineration;

neration : by distillation with a gentle heat, part of the acid comes over dissolved in the water of crystallization : another portion sublimes undecomposed in the form of silky crystals ; and a strong heat separates a few drops of oil, with fixed and inflammable air.

The acid of galls is soluble in twenty-four parts of cold water, or three of boiling water. It is much more soluble in spirit of wine ; four parts of this being sufficient at the common temperature, or one when boiling hot. With lime, magnesia, or ponderous earth, it forms salts which are soluble in water : it unites readily with the alkalis, and forms compounds which have not been much attended to. The action of the nitrous acid converts it into the acid of sugar. This acid precipitates gold, silver, mercury, copper, iron, and bismuth, from their solutions ; but it does not affect those of platina, zinc, tin, cobalt, and manganese.

ACID, MARINE, or THE ACID OF SEA SALT, known in commerce by the name of spirit of salt. As common salt consists of this peculiar acid united with the mineral alkali, by so strong an affinity that both substances may be driven up by heat, instead of any separation taking place, the acid itself cannot be obtained alone, but by means of processes, in which a third substance is presented to combine with the alkali. Various methods were formerly used, in which the common salt was ground together with earthy substances, and then exposed to distillation. These methods have been discontinued in England since the vitriolic acid has been obtained at an easy rate from sulphur. In the ancient method, common salt was previously decrepitated, then ground with dried clay, and kneaded or wrought with water to a moderately stiff consistence, after which it was divided into balls of the size of a pigeon's egg : these balls being previously well dried, were put into a retort, so as to fill the vessel two thirds full ; distillation being then proceeded upon, a spirit of salt came over when the heat was raised to ignition. In this process eight or ten parts of clay to one of salt are to be used. The retort must be of stone ware well coated, and the furnace must be of that kind called reverberatory.

It was formerly thought that the common salt was merely divided in this operation by the clay, and on that account more readily gave out its acid : but there can be little doubt that the effect is produced by the siliceous earth which abounds in large proportions in all natural clays, and detains the alkali of the salt by combining with it.

The extrication of marine acid from common salt, by means of vitriolic acid, is much the most elegant and effectual. The English manufacturers use iron stills for this distillation, with earthen heads : the philosophical chemist will doubtless prefer glass. One part, by weight, of strong vitriolic acid is to be added to three of decrepitated sea salt, in a retort whose upper part is furnished with a tube or neck, through which the acid is to be poured upon the salt. The aperture of this tube must be closed with a ground stopper immediately after the pouring. The vitriolic acid immediately combines with the alkali, and expels the marine acid in the form of a peculiar air, which is rapidly absorbed by water, but may be confined by mercury. As this combination and disengagement take place without the application of heat, and the aerial fluid escapes very readily, it is necessary to arrange and lute the vessels together before the vitriolic acid is added, and not to make any fire in the furnace until the disengagement begins to slacken ; at which time it must be very gradually raised. Before the modern improvements in chemistry were made, a great part of the acid escaped for want of water to combine with ; but by the use of Woulfe's apparatus (See APPARATUS), the acid air is made to pass through water, in which it is condensed, and forms marine acid of double the weight of the

water, though the bulk of this fluid is increased one half only. The acid condensed in the first receiver, which contains no water, is of a yellow colour, arising from the impurities of the salt.

Heat expels the marine acid air from marine acid, and leaves the water behind. The fumes of spirit of salt consist of this air in the act of uniting with the watery vapours of the atmosphere, which render it visible. The air has nearly the same affinities as the acid itself in the fluid form. The electric explosion diminishes it a little; but the remainder is almost totally soluble in water as before.

In the action of acids upon other bodies they may be considered to operate either as entire substances, or by virtue of the disposition which their component parts may respectively have to combine with the substance acted on. One of the most general actions of acids is that which answers the same purpose as combustion, either by depriving bodies of phlogiston, or communicating vital air to them, or both. The acids which are most effectual in this respect are the most easily reduced to their component parts. The marine acid in its ordinary state has very little effect upon combustible bodies, and is not susceptible of changes, by their mutual action, similar to those which the vitriolic and nitrous acids undergo in like circumstances. Its action on oils and ardent spirits is not considerable.

The aeriform marine acid acts more strongly in a variety of instances than that which is diluted with water in the fluid state. When this acid air is in contact with spirit of wine, oil of olives, oil of turpentine, charcoal, phosphorus, bees wax, or sulphur, it produces inflammable air. The theory of this effect will be, either that it dislodges phlogiston from these inflammable substances, or else that it combines with them at the same time that a decomposition of the water, which composes a large part of all aerial substances, ensues; the vital air of the water combining with the inflammable substance, and burning it, while the inflammable air, or other component parts of the same water, is set at liberty. In this, as in a great variety of instances, the doctrine of the composition and decomposition of water comes to the assistance of the new theory; and if this position could once be overthrown, the present experiments, and others of the like nature, would afford the strongest proof of the existence of inflammable air, or a general principle of combustibility in inflammable substances, or at least in the acids applied to them, since it must come from the one or the other.

Spirit of wine absorbs the aerial marine acid as readily as water itself does, and is increased in bulk by that means. When this fluid is saturated, it dissolves iron with great rapidity, but nevertheless continues inflammable. When this air is added to a considerable quantity of oil of olives, it is absorbed very slowly, at the same time that the fluid turns almost black, becomes glutinous, less miscible with water, and acquires a disagreeable smell. By continuing upon the surface of the water it became white, and its offensive smell went off in a few days. Oil of turpentine absorbs this air very fast, turning brown, and almost black. No inflammable air was formed till more of the acid air had been raised than the oil was able to absorb: the same was the case with the oil of olives. Bees wax absorbs the aeriform marine acid very slowly, and produces inflammable air. Charcoal absorbs this acid air very fast, rendering one fourth of it immiscible with water, and weakly inflammable. A small bit of phosphorus smoked and gave light in the acid air, in the same manner as it would have done in common air equally confined. When water was admitted to this air, it absorbed the whole, except one fifth, which was weakly inflammable. Sulphur absorbs marine acid air slowly, and leaves an inflammable remainder, which burns with a blue flame. Ether absorbs it very fast, becoming first of a turbid white,

and then of a yellow and brown colour. This saturated fluid is very volatile and inflammable, and the combination affords inflammable air. Camphor is rendered fluid by imbibing this acid air, but recovers its former solid state upon the addition of water. Some vestiges are exhibited in this experiment, of a combination having taken place between a minute portion of the acid and the camphor, attended with a production of inflammable air.

Marine acid air extinguishes flame, and is much heavier than common air. The electric spark is visible in marine acid air exactly as in common air: neither the spark nor the explosion, in the hands of Dr. Priestley, produced any change in this air which might not have been ascribed to some casual circumstance. In the experiment with the great Harlem machine, a diminution of about one eighteenth took place in the course of five minutes, after which the passage of the electricity was resisted: a shorter spark was then applied for twenty-five minutes, which did not produce any perceptible alteration, and the air was as readily absorbed by water as if it had not been electrified.

The marine acid in commerce has a straw colour: but this is owing to accidental impurity; for it does not obtain in the acid produced by the impregnation of water with the aeriform acid.

The marine acid, in combination with the vegetable alkali, forms a salt, called salt of Sylvius, or improperly regenerated sea salt: it is of a bitter taste, slightly deliquescent, and soluble in about three times its weight of water. This is sometimes used in medicine.

With the mineral alkali it forms common sea salt.

With the volatile alkali it forms common sal ammoniac; which is a consistent salt of a sharp briny taste, and so remarkably deficient in the usual brittleness of this class of bodies, that it is not easily pulverised. It is soluble in between three and four times its weight of water, in a common temperature. By heat it sublimes entire in closed vessels.

The saline combination of lime with marine acid is sometimes called marine felenite, and sometimes fixed ammoniac, because it forms the fixed residue after sal ammoniac has been exposed to distillation with lime. This salt may be obtained in the form of crystals, but it deliquesces in the air. It is soluble in less than twice its weight of cold water. The combination of lime and marine acid which remains after distilling sal ammoniac has usually an over proportion of lime. If it be urged by a violent heat, it fuses; and when cold, it has the property of emitting a phosphoric light upon being struck with any hard body. Hence it is called *Homborg's phosphorus*, from the name of the first observer.

The argillaceous marine salt has a gelatinous consistence, when dissolved in a small quantity of water. Its taste is styptic, and it affords crystals by spontaneous evaporation.

The combination of ponderous earth with marine acid forms a crystallizable salt of difficult solution. Its solution is of admirable use for detecting the presence of the vitriolic acid in any fluid; because this last acid combines with the earth, and forms an insoluble precipitate of ponderous spar. It is more especially useful for purifying the marine acid itself from the vitriolic acid which it often contains. The exact quantity of solution necessary to be added for this purpose, to any vessel of marine acid, may be known by previous trials with small portions of the acid.

Magnesian marine salt exists in all salt waters. It is soluble in less than its own weight of water; and cannot be obtained in the crystalline form, but by first evaporating its solution, and then suddenly exposing it to a great degree of cold. It is the
cause

cause of the bitterness of sea water ; and, like most of the other salts last described, it is applied to no useful purpose.

The marine acid acts directly upon tin, lead, copper, iron, zinc, bismuth, antimony, manganese, arsenic ; but does not affect gold, silver, platina, mercury, wolfram, nor cobalt.

When the strongest marine acid is mixed with spirit of wine, there is no considerable heat excited, and scarcely any combination takes place ; but the dephlogisticated or aerated marine acid is capable of converting ardent spirit into an ether.

ACID, MARINE AERATED, *or* DEPHLOGISTICATED. If the marine acid be distilled from about one fourth of its weight of the black calx of manganese, a suffocating elastic fluid arises, which corrodes mercury, and is absorbed by water. If the concentrated acid be used, the disengagement takes place without heat ; but if it be weaker, a gentle heat is necessary. This operation may conveniently be performed in the apparatus of vessels fig. 2. The common marine acid which may rise is condensed in the first bottle, and the dephlogisticated acid vapour unites to the water in the second : the water, as it becomes saturated, assumes a greenish yellow colour. When the saturation is complete, the dephlogisticated acid takes a concrete form, and descends to the bottom in yellowish flocks, provided the temperature of the water be only a few degrees above freezing. An increase of temperature, such as may be produced by applying the hand to the vessel, causes this concrete matter to assume the aerial form, and escape in bubbles to the surface. The taste of the solution is austere, but does not resemble that of acids. It combines with fixed alkalis without causing them to give out their fixed air, if they be in a mild state. Heated with lime or fixed alkali, it emits vital air, and then forms the same saline combinations as the common marine acid would have done with them. It dissolves all metals directly, without affording inflammable air as the marine acid does with some of them, and its saline combinations are, for the most part, the same as the common marine acid produces when made to combine with them. Of these, however, we shall have occasion to treat more fully under the respective metals. It destroys vegetable colours, rendering them white, without first causing them to become red ; and it bleaches wax.

When the aeriform dephlogisticated marine acid is received in a solution of pure vegetable alkali, and the liquor evaporated, two kinds of salt are obtained. The one is the common salt of Sylvius, which separates from the fluid as the evaporation goes on ; and the other is a salt which, being more soluble in hot than cold water, affords crystals by cooling. These are of a rhomboidal figure, and a silvery brilliancy ; have an insipid, cooling taste resembling nitre ; do not deliquesce in the air, and detonate with charcoal or with iron more strongly than nitre itself. This salt has been made into gun-powder of great force by trituration with charcoal and sulphur. By heat alone this salt gives out vital air, and the residue of the detonation with charcoal, is the salt of Sylvius, or vegetable alkali saturated with marine acid. From these circumstances it is evident, that a portion of the alkali imbibes the dephlogisticated marine acid, together with a portion of the vital air which was employed in dephlogisticating or aerating the remainder of the marine acid ; and that this alkali forms the detonating salt, while the acid which was deprived of the overplus of air, and by that means reduced to the common state, forms the salt of Sylvius, which is in much the greatest proportion in the solution.

When a mixture of one ounce and a half of manganese with five ounces of concentrated marine acid, and three of ardent spirit, is exposed to distillation by a very gentle heat, there is scarcely any production of elastic vapours, but a quantity of ethereal liquor slightly acid. In this process, the whole of the dephlogisticated acid appears to have united with the ardent spirit, and formed an ether.

The dephlogisticated marine acid, in the aeriform state, acts somewhat more powerfully upon bodies than when combined with water.

Much light has been thrown upon a variety of chemical appearances by this capital discovery of Scheele, in which the marine acid is so considerably changed. Of these we shall have occasion to speak as they present themselves; for which reason we shall confine our attention in the present article to such observations as tend to elucidate the theory of this conversion.

In the ancient theory, metals, being supposed to consist of a calx united with phlogiston, are supposed to be dissolved in acids, either merely, or at least chiefly, by the medium of part of their phlogiston, to which the acid is supposed to have an attraction. For acids, being produced by the combustion or dephlogistication of inflammable substances, possess more or less of a disposition to resume their combustible state according to the nature and conditions of affinity under which phlogiston is presented to them. The marine acid, having a comparatively weak action upon metals and other combustible bodies, was of course, therefore, presumed to contain naturally a larger portion of phlogiston. The black manganese is a calx of that semi-metal, which has a strong tendency to become reduced to the metallic state, or, according to the same enunciation, to attract phlogiston. This therefore is what it does when it comes in contact with the marine acid at a proper temperature: It dephlogisticates the acid, whose properties become by that means changed, inasmuch that it is rendered eminently capable of acting on combustible bodies, which at the same time restore its original state by again adding the phlogiston before attracted by the manganese.

The facility and perspicuity of this explanation will be readily seen, and it was for a time admitted without controversy. It is probable, indeed, that the science of chemistry might never have afforded a better, if less attention had been paid to the elastic products which are of so much importance in every operation, though the science of their effects is so very modern. It is from the examination of these permanently elastic substances, that the phlogistians have found themselves under the necessity of admitting other effective causes in the combustion of bodies, besides the mere transition of their inflammable principle; and from this it is that their opponents have been induced to maintain, that these other effective causes are sufficient to solve the phenomena without the aid of that principle. How far the matter of heat emerging from a latent state by the change of capacity in bodies may interrupt the general reasoning, cannot perhaps be determined, while we know so little of that subject as leaves even its separate existence a matter of controversy. But the transitions of the respirable part of the atmosphere, or vital air, in combustion being matter of fact, which consequently demands admission in our explanations, tends immediately to bring forward the question, how far those transitions afford an adequate result without supposing any other substance. On the subject before us, the antiphlogistian philosophers take notice, that manganese contains vital air, as is proved by its emitting that fluid when heated; and as they state the act of combustion to consist in the combination of vital air with any other body, they consider the marine acid in that state which was called dephlogisticated, to be the acid combined with a larger proportion of vital air than it possesses in its ordinary state. Its strong action on combustible bodies does not therefore, according to them, consist in depriving them of phlogiston, but in communicating that vital air which is necessary to burn or calcine them, and which, in their theory, forms the medium of the solution of metallic calces in the same manner as phlogiston does in the former theory.

Whatever reasons the cautious philosopher may find to doubt the stability of either theory, it is evident that the facts may be generalized without them. The dephlogisticated marine acid is obviously removed farther from the state of a combustible body

body than the common marine acid ; whence it acts on all combustible bodies more strongly. It appears worthy of remark, however, that its acidity with respect to alkalis and earths is not increased by this treatment, but on the contrary seems, as far as can be collected from circumstances, to be diminished. If this fact were clearly established, the marine acid would follow a contrary law to that of the vitriolic and nitrous acids, which retain alkalis more strongly, the more perfectly they are dephlogisticated, or the larger the quantity of vital air which enters into their composition. It must nevertheless be noticed, that the phlogisticated nitrous and vitriolic acids require a larger quantity of alkali for their saturation than before, though they retain it less strongly.

ACID OF MILK. When milk is exposed for some hours in a state of repose, a small quantity of thick fluid rises to the top, and is known by the name of cream. This contains the fat substance called butter, which may be separated from it by agitation in the act of churning. The remainder afterwards becomes sour, and undergoes coagulation, which separates it into two parts—a solid curd, and a fluid called serum or whey. This four whey contains a peculiar acid, called the acid of milk, and likewise a portion of vinegar. The peculiar acid does not rise in distillation, but may be separated by evaporating the filtered whey to one eighth ; and precipitating the phosphoric salt by the addition of lime water, which fully saturates its acid : the fluid is then to be diluted with three times its weight of water, and the lime precipitated by saccharine acid ; in which operation the excess of the last-mentioned acid may be guarded against by the test of a small portion of lime water. This purified liquor must then be evaporated to the consistence of honey ; and the other foreign substances it may contain will be separated by the addition of pure ardent spirit, which takes up the acid of milk only. The decanted solution being then diluted with water, and heated, the ardent spirit flies off, and leaves the acid of milk behind, dissolved in the water.

This acid does not afford crystals ; and, when evaporated to dryness, it deliquesces again by exposure to air. With mineral alkali it affords a salt possessing the same properties. With volatile alkali it produces a deliquescent salt, which yields much of its alkali by distillation before the acid is destroyed by heat. With lime, clay, and ponderous earth it forms deliquescent salts ; but with magnesia it affords small crystals, which at length deliquesce. The acid of milk dissolves iron and zinc, and produces inflammable air. Copper affords a dark blue solution, which does not crystallize. Lead is dissolved after some days digestion, and affords vestiges of vitriolic acid. Bismuth, cobalt, antimony, tin, mercury, silver and gold, are not affected by this acid in a digestive or boiling heat. Destructive distillation decomposes the acid of milk : water first comes over ; then a weak acid resembling the empyreumatic acid of tartar ; afterwards some empyreumatic oil, with more of the same acid, and also fixed air, and the heavy inflammable air. A coal remains in the retort.

ACID OF MOLYBDENA. Molybdena is a substance which greatly resembles plumbago or black lead ; but its texture is scaly, and it is not easily pulverized, on account of a degree of flexibility which its laminæ possess. It may however be reduced to powder by grinding in a mortar with some vitriolated tartar ; the hardness and angular figure of the particles of this salt tending greatly to facilitate the division. The salt may afterwards be washed off by three or four affusions and decantations of hot water.

None of the known acids have any effect upon molybdena, except those of arsenic and of nitre. The molybdena is not attacked by the acid of arsenic till the water is evaporated. If then the heat be increased a little, arsenic rises into the neck of the retort,

retort, and towards the end of the operation yellow arsenic or orpiment is sublimed. Volatile sulphureous acid goes over into the receiver.

The concentrated nitrous acid being poured upon powdered molybdena in the proportion of two parts of the former to one of the latter; the mixture was scarcely warmed in the retort, before the whole mass passed over into the receiver with great heat. Scheele considers this mixture as in danger of taking fire when the quantity is large, and therefore uses the diluted nitrous acid.

Six ounces of diluted nitrous acid were distilled from one ounce and a half of the powdered molybdena. No effect took place during the digestion; but as soon as the mixture began to boil, red vapours were extricated with great intumescence, so that it is necessary to use a large retort. The distillation was continued to dryness; after which the same quantity of nitrous acid was again poured on the residuum, and distilled off with the same appearances as before. This process was again and again repeated until the fourth or fifth time; the residual powder becoming less and less in quantity, until at last it consisted of six drams and a half of white pulverulent matter resembling chalk. This substance, by edulcoration with hot water, afforded some acid of vitriol and a small quantity of iron. The white pulverulent matter is the acid of molybdena. It exhibits weak acid properties. Molybdena may likewise be converted into the acid state by detonation in a red hot crucible with four times its weight of purified nitre. The reddish alkaline mass which remains is to be dissolved in water, and affords both vitriolated tartar and nitre by evaporation. The remaining lixivium appears to consist of a combination of the acid of molybdena with a portion of the alkali. This acid falls down, upon the addition of diluted vitriolic acid; which however must be cautiously added, because an excess will suspend the precipitate; and if the solution be hot, no precipitate whatever ensues. The nitrous or marine acids may likewise be used in this process, instead of the vitriolic. It is not easy to deprive this precipitate of the last portions of alkali.

The acid of molybdena requires about five hundred times its weight of water to dissolve it; and the solution reddens lacmus, coagulates the solution of soap, and precipitates liver of sulphur. The addition of vegetable alkali forms a salt which is much more soluble in water than the pure acid itself, and affords crystals by evaporation. This neutral salt does not rise by the action of heat, like the pure acid itself. With volatile alkali it forms a neutral salt, which parts with its alkali in a gentle heat. The solution of the acid of molybdena expels fixed air from chalk or magnesia, and effervesces with earth of alum, forming salts of difficult solution with these earths. It precipitates ponderous earth from its nitrous or marine solutions, and forms a neutral compound very sparingly soluble in cold water; but it does not precipitate the solution of other earths. It precipitates silver, mercury, and lead from the nitrous acid, and also lead from the marine acid. These precipitates are reduced by the blow-pipe upon charcoal, at the same time that the acid is absorbed. The other metals are not precipitated. The neutral alkaline salts of molybdena precipitate all metallic solutions. Gold, corrosive sublimate, zinc and manganese are precipitated in the form of a white powder; iron and tin from their solution in marine acid of a brown colour; cobalt, of a rose colour; copper, blue; and the solutions of alum and quick lime, white.

The concentrated vitriolic acid dissolves a considerable quantity of the acid of molybdena, the solution becoming of a fine blue colour as it cools, at the same time that it thickens: the colour disappears again on the application of heat, but returns again by cooling. A strong heat expels the vitriolic acid. The nitrous acid has no effect on it; but the marine acid dissolves it in considerable quantity, and leaves a dark blue residuum when distilled. With a strong heat it expels a portion of vitriolic acid

acid from vitriolated tartar. It also disengages the acid from nitre and common salt by distillation. It has some action upon the filings of the metals in the moist way.

When molybdena is fused with a fixed alkali, it forms an hepatic compound, that affords sulphur by precipitation; from which circumstance the presence of sulphur in this mineral is ascertained. The same fact is likewise ascertained from the presence of vitriolic acid in the analysis of molybdena, when it is acidified by the abstraction of nitrous acid. This truth is also ascertained synthetically. When the acid of molybdena is heated with sulphur in a retort, placed in such a manner as that the sublimed sulphur may melt and run back again, a combination between these two substances is at length produced, and the superfluous sulphur flies off, being partly converted into volatile vitriolic acid. The residue is found to be, in every respect, the same as the native molybdena. The analysis of molybdena by the nitrous acid, shewed that it consists of sulphur united to a peculiar acid, or acid basis; and this synthetical production of molybdena proves the same thing.

ACID NITROUS, or THE SPIRIT OF NITRE OF COMMERCE. This acid is obtained by distillation with an intermedium, nearly in the same manner as in the manufacturing of the marine acid. In the process for making that spirit of nitre, which is called aqua fortis, two parts of dry and powdered clay are well mixed with one part of nitre in a stone ware retort, to which a vessel of the same form and kind is luted as a receiver. The distillation is effected by an heat gradually raised to ignition in a reverberatory furnace. The siliceous earth with which the clay abounds unites with the alkali of the nitre, and sets its acid at liberty. Very good spirit of nitre may be made in this way; but the manufacturers seldom use any considerable degree of care, on account of the low price at which they sell the product. The nitre they make use of in general contains common salt; from which circumstance the aqua fortis is often vitiated by an admixture of marine acid.

Spirit of nitre is obtained either by the intermedium of martial vitriol, or of the vitriolic acid itself. In the first method the vitriol is deprived of its water of crystallization by heat, and then mixed with an equal weight of very pure nitre, both substances being previously pulverized. They are then poured into a good earthen ware retort through a paper funnel, which passes into the belly of the retort, and prevents any of the powder from adhering to its neck. The retort is placed in a reverberatory furnace upon an earthen dish filled with sand. A large glass balloon or receiver is to be fitted and luted to the retort with fat lute, round which is to be wrapped a cloth soaked in a thin paste of the white of eggs, and slacked lime. It is necessary that the receiver should have a small hole in its upper part, for the elastic vapours to escape. The distillation must be commenced with a very flow fire. Red vapours are soon extricated, and the spirit of nitre passes over in drops. As soon as the retort is red hot, and the vapours cease to come over, the fire must be slackened and suffered to go out; and when the vessels are cooled, the receiver must be cautiously withdrawn, and its contents quickly poured through a glass funnel into a clean and dry glass bottle, which is to be immediately afterwards closed with a glass stopper. Great care must be taken to avoid the fumes which arise during the pouring of this acid. The best method of doing this, consists in standing in a current of air, so that the vapours may be blown from the operator. Other precautions are likewise necessary in the management of the heat, and the occasional opening of the small hole of the receiver. But these difficulties are in a great measure removed by the pneumatic apparatus of Woulfe. See APPARATUS.

The spirit of nitre obtained in this way is of the kind called phlogificated, and emits copious fumes, which assume a dark red colour when they mix with the air.

The method of distilling nitrous acid from nitre by the intermedium of vitriolic acid is much more easy, quick and convenient than the foregoing. It is performed by putting a quantity of very pure nitre into a stone ware or glass retort. Upon this one third part of highly concentrated vitriolic acid is to be poured through a glass funnel, the stem of which ought to be sufficiently long to reach into the belly of the retort. The receiving apparatus must be adopted as in the foregoing operation, and the process must be conducted with similar precautions.

If it be suspected that any portion of vitriolic acid may have passed over towards the end of the operation, the acid may be rectified by distillation from a portion of very pure nitre. The quantity of nitrous acid obtained in this way, is about five eighths of the weight of the nitre.

When nitrous acid is suspected to be adulterated with marine acid, it is purified by the addition of small portions of the nitrous solution of silver, which is to be added as long as any precipitate falls down. The precipitate consists of the silver united with marine acid. It is advantageous in the first place to ascertain the due quantity of metallic solution necessary to be added to a large quantity, by making experiments with smaller quantities of the two fluids.

The obvious characters of nitrous acid, are : 1. It is of a yellow or reddish colour, but may be rendered pellucid by a slight boiling in a retort, which expels a quantity of elastic fluid, known by the name of nitrous air. 2. It emits yellow fumes, which consist of nitrous air in the act of uniting with the vital air of the atmosphere. 3. Its greatest specific gravity is 1580 : 1000 compared with water, and it has a considerable degree of volatility. 4. When highly concentrated, it strongly attracts the humidity of the atmosphere. 5. It develops a considerable degree of heat when mixed with water, but when mixed with ice it produces intense cold. 6. A certain proportion of water converts its colour to a deep blue or green, while the vapours still continue of their original yellowish red. 7. The action of light expels vital air from the pale nitrous acid, at the same time that the acid obtains a deeper or yellowish colour.

This acid in combination with calcareous earth forms a salt, whose crystals deliquesce by exposure to the air, and are soluble in twice their weight of cold, or their own weight of boiling water. With ponderous earth, it forms a salt of difficult solubility. With magnesia, it forms an acid bitter salt, which is very soluble in water, and deliquescent in the air. With clay, it forms an austere salt of difficult solution. None of these have yet been applied to any use.

With the vegetable alkali this acid forms common nitre ; a salt whose production, and the influence its uses have had upon civil society, render it an object worthy of the most particular attention. See NITRE and GUN-POWDER.

With the mineral alkali, it forms a salt, called quadrangular nitre, from the usual form of its crystals. About three times its weight of water is required to hold it in solution in a mean temperature, and it is scarcely more soluble in hot water. Its properties resemble those of common nitre ; but it is less fit for making gun-powder, because it attracts the humidity of the air.

The nitrous acid in combination with the volatile alkali forms nitrous ammoniac, a salt which slightly attracts the humidity of the air, and is soluble in less than its own weight of water. If this salt be exposed to heat in closed vessels, it suddenly explodes ; part of the acid and alkali are destroyed, and the aerial product is phlogisticated air.

There is no part of chemical science more eminently instructive, or more fruitful in its consequences, than that which relates to the nitrous acid. In many instances, it is composed, and in others decomposed, or reduced to its component parts ; and it has been in a great measure, from the analogies afforded by the phenomena of this acid,

acid, that the general and very perspicuous modern doctrine of the nature of acids has been derived.

It has long been well known, that the nitrous acid, instead of existing in considerable masses in the mineral kingdom, like the vitriolic and marine acids, is almost always produced by a concurrence of circumstances, chiefly consisting in the exposition of putrefying substances to the atmosphere, together with a calcareous or other base to receive the acid. Upon these facts was founded the popular notion of nitrous particles existing in the air. Messrs. Thouvenels, in their memoir which gained a prize from the Academy of Paris, relate a variety of experiments in which the natural process of the formation of nitre was imitated. They observe that calcareous earths, in the mild state, are the fittest bases for the reception or production of nitre; that magnesia and clay have very little effect, and alkalis none at all; that the presence of atmospherical or vital air is necessary in this process, but no length of exposure of the calcareous bases to vital air alone is sufficient to produce nitre; that none of the permanently elastic fluids or airs afford nitrous acid, excepting air impregnated with putrid effluvia; and that this air was deprived of its virtue in this respect by washing in lime water, or in a caustic alkali. From these experiments, which were performed by exposure of the substances respectively to each other during a long course of time in very large glass vessels, it appears to be established, that nitrous acid is produced by the union of two or more principles which are always found in atmospherical air, and in the exhalations from putrid substances. But it is to Mr. Cavendish that we are indebted for the capital discovery, that nitrous acid is produced when a mixture of phlogisticated and of vital air is exposed for a long time to the action of the electric spark.

This * experiment was performed by enclosing a mixture of two parts, by measure, of vital air, obtained without the use of nitrous acid, and one of phlogisticated air, or, which is the same thing, five parts of vital and four of common air, in the upper part of a syphon in which it was confined by mercury. The legs of the syphon stood in two small glass vessels separately insulated, to one of which the electric sparks were communicated, and passed off to the common stock through the other. A small quantity of soap lees, or solution of caustic alkali, was admitted into the cavity which contained the air. This is a slow operation, and requires the quantity of air to be renewed very often, to supply the absorption which takes place. The absorbed matter is found to consist of nitrous acid, as is plainly proved by the existence of true nitre in the soap lees. When the electricity is strong, no indication of the soap lees becoming saturated is afforded by any cessation in the diminution of the air; but the nitrous acid continues to be absorbed, and enters into combination with some of the mercury. This admixture of mercurial nitre prevents the deflagration of paper dipped in the soap from being so vivid as it would otherwise have been. Mr. Cavendish apprehends that the quantity of acid produced, and consequently the saturation of the soap lees depends only on the quantity of phlogisticated air absorbed, and that the effect of the greater or less quantity of dephlogisticated air is only to make the nitre produced more or less phlogisticated. In the experiment performed in the year 1787, the bulk of the phlogisticated air was $12 \frac{2}{5}$ that of the soap lees. In Mr. Cavendish's first experiment, it was $11 \frac{1}{10}$, and in his last $10 \frac{8}{10}$.

The reasoning of philosophers upon this leading fact has been as various as their respective notions concerning the composition of the two airs. Those who believe that the fluid called phlogisticated air does consist of an elastic fluid containing a

* Consult Mr. Cavendish's papers in the Philosophical Transactions, vol. lxxv. and vol. lxxviii.

considerable portion of phlogiston, have supposed that the vital or dephlogisticated air, by the process of combustion, deprived the phlogisticated air of the principle of inflammability; so that the nitrous acid with them is the basis of phlogisticated air. Others, perhaps with equal probability, have supposed that the nitrous acid was produced by the union of vital air with a due proportion of the inflammable principle obtained from the phlogisticated air: and lastly, the chemists who reject phlogiston altogether, and are desirous of considering all bodies as simple until they are proved by experiment to be compounded, affirm that the two airs which disappear in this experiment, have combined together, and, consequently, that nitrous acid is a compound of vital air and phlogisticated air. Whichsoever of these inferences be employed in the general explanation of the facts, it is evident, that a certain degree of consistency will attend the explanation throughout, because, generally speaking, the insertion of suppositions which, though not fully warranted by experiment, are not contradictory to the facts we are in possession of, will not be productive of absurdity, though it tends greatly to lessen the simplicity of any explanation. In the rest of this article we shall however, as the safest and least intricate method of proceeding, consider the nitrous acid as composed of vital and phlogisticated air, without entering into the enquiry whether those airs be simple or compound bodies, relative to the present state of our knowledge.

Nitrous acid has been lately produced by the Rev. Isaac Milner *, of Cambridge, in a less simple though very perspicuous and elegant manner. He exposed the volatile alkali in the aerial form, to vital air, at the instant of its extrication from manganese ignited in a gun-barrel. The manganese was used in rough powder, for when it is too finely powdered, the tube becomes choked up. Caustic volatile alkali was contained in a retort affixed to the end of the gun-barrel, and this was made to emit alkaline air by boiling. At the other end of the gun-barrel was a tube which passed beneath a pneumatic apparatus. It must be imagined of course that the manganese occupied the middle of the gun-barrel, at which place the heat was applied to ignite it. The consequence was, that nitrous air came out of the end of the gun-barrel at the time that the alkaline air was introduced at the other end: but this effect did not take place without the presence of the alkaline air. Mr. Milner observes, that there is a cause of deception in the experiment, against which the operator ought to be on his guard, lest he should conclude that no nitrous air is formed, when in reality there is a considerable quantity. The volatile alkali, notwithstanding every precaution, will frequently pass over in great quantities undecomposed. If the receivers are filled with water, a great part of this will indeed be presently absorbed; but still some portions of it will mix with the nitrous air formed by the process. Upon admitting the atmospheric air, the nitrous air is decomposed, and the red nitrous fumes instantly combine with the volatile alkali. The receivers are presently filled with white clouds of nitrous ammoniac; and in this manner a wrong conclusion may easily be drawn, from the want of the orange colour of the nitrous fumes. A considerable quantity of nitrous air may have been formed, and yet no orange colour appear, owing to this circumstance; and therefore it is easy to understand how a small quantity of nitrous air may be most effectually disguised by the same cause.

This acute chemist, considering that there are many other substances besides the calx of manganese which are known to afford dephlogisticated air, was induced to make the experiment, whether they would not also afford nitrous air upon the application of volatile alkali. With red lead, his experiments did not succeed; but he

* Philosophical Transactions, vol. lxxix, page 306.

finds it difficult to persuade himself that it would not answer with a more perfect apparatus than that used by himself. With calcined martial vitriol he had much better success. The salt was calcined to whiteness, and put into a gun-barrel; and after several trials of forcing the volatile alkali through the hot tube, he procured some ounces of strong nitrous air.

As calcined green vitriol affords vital air when urged by a strong heat, he had no doubt, after this experiment, but that any substance possessing the same property might, by similar treatment, be made to afford nitrous air. But in this supposition he found himself entirely mistaken. The volatile alkali was applied to some calcined alum at the moment when it was yielding, in a strong heat, plenty of dephlogisticated air. The product was an astonishing quantity of inflammable air mixed with hepatic air and actual sulphur. The residuum of the alum had a strong hepatic smell, and contained particles of perfectly formed sulphur.

Most of the experiments, if not all, were repeated in earthen tubes instead of gun-barrels, and with the same success.

After premising a circumstance of which we have not yet spoken, namely, that nitrous air spontaneously unites with vital air, and forms nitrous acid; from which and other facts it is seen that nitrous air consists of the acid in an imperfect state, for want of a due proportion of vital air; and consequently that the production of nitrous air may be considered as a production of nitrous acid: we cannot do better than add the explanation or theory of the foregoing facts in the words of the author.

“ 1. Nitrous air and dephlogisticated air, by mixture, produce nitrous acid; and nitrous acid, by mere heat, is converted into a mixture of phlogisticated and dephlogisticated airs.

“ 2. Nitrous air, by the methods already related, is changed into phlogisticated air; and these methods seem to consist in abstracting from the nitrous air a quantity of dephlogisticated air.

“ 3. When nitrous acid and nitre are produced in a natural way, the process is not well understood; but the presence of the atmosphere is known to be necessary.

“ 4. Mr. Cavendish's experiment is decisive on this point. The union of the two airs in question is effected by means of the electrical spark, and nitrous acid is the product.

“ In the next place we are to consider, that volatile alkali contains phlogisticated air; for,

“ 1. Volatile alkali, by mere heat, or by the electrical spark, is changed into a mixture of phlogisticated and inflammable air; and,

“ 2. The residuum of volatile alkaline air, after the calces of the lead have been revived in it, is phlogisticated air.

“ Therefore, when volatile alkali, in the form of fume or air, is applied to red hot manganese, or calcined green vitriol (substances which are then yielding dephlogisticated air), with these facts in view, it seems not difficult to conceive, that one of the ingredients of the alkali, viz. phlogisticated air, should combine with dephlogisticated air, and form nitrous acid or nitrous air. If nitrous acid be formed, it will indeed, in that heat, as has been observed, be instantly decomposed; but if the effect of the union be nitrous air, that will sustain the heat without decomposition. How it happens, that nitrous air should be formed, and not nitrous acid, or what the reason is, that nitrous air can sustain a red heat without decomposition, when nitrous acid cannot, I am unable to say; and it is better to acknowledge our ignorance than advance groundless conjectures. So much, I think, may be pronounced

as certain, viz. that nitrous air contains less dephlogisticated air than nitrous acid ; because it requires the addition of dephlogisticated air to become nitrous acid.

“ And lastly, if I mistake not, the experiment with the calcined alum proves, that, in order to produce nitrous air, it is not sufficient merely to apply volatile alkaline air to a substance which is actually yielding dephlogisticated air.

“ Perhaps the presence of another substance is required, which has a strong attraction for phlogiston. Perhaps, in the experiments with the calces of manganese and of iron the inflammable principle of the volatile alkali combines with the calces of the metals, and the phlogisticated air, the other component part, unites with the dephlogisticated air; and if so, it seems not improbable to suppose, that when alum is made use of, the inflammable principle of the volatile alkali having little or no attraction for clay, the basis of the alum should combine with its acid, and form sulphur. If this reasoning be true, then it follows, that the vitriolic acid has a stronger affinity to the inflammable principle than it has to phlogisticated air ; and the process with the green vitriol and manganese is to be explained by the operation of a double affinity : the inflammable principle of the volatile alkali joins with the calx of iron, the basis of the vitriol, or with the manganese, and the phlogisticated air with the dephlogisticated air produced by the acid in the red heat.

“ Those who choose to reject the doctrine of phlogiston must make the necessary alteration in these expressions : but the reasoning will be much the same.”

The experiments which shew the decomposition of nitrous acid are not less instructive than those which prove its composition. When pale nitrous acid is exposed to the action of light, there is an emission of vital air, and the colour of the acid becomes deeper than before.

This effect of light appears to take place upon the nitrous vapour in which the dephlogisticated air is rendered permanently elastic, while the imperfect acid or nitrous air is absorbed by the fluid. It should seem therefore that the dephlogisticated or vital air is more disposed to assume the permanently elastic state than the other component part, namely, the phlogisticated air, which last appears obstinately to retain a portion of the vital air, so as to preserve the form of nitrous air.

Mere heat, applied to the acid by boiling it in glass tubes of a sufficient capacity or length to admit of the operation being performed in perfect safety, effects the same thing. Vital air is emitted, and the acid becomes of a deeper colour, or phlogisticated. In these facts *, however, there are circumstances which appear to indicate that the processes are not quite so simple as here stated. The dephlogisticated air emitted is by no means perfectly pure ; and when the upper part of the tube is previously filled with phlogisticated or with inflammable air, the quantities of these are diminished. These circumstances seem to indicate either a decomposition of the water, or a greater degree of composition in the respective aerial substances, particularly the phlogisticated air, than chemists have of late years been habituated to allow. In the usual distillation of nitrous acid the same decompositions take place, according to the degree of heat, the quantity of vital or respirable air extricated being greater, and the acid of a deeper colour, the stronger the heat.

The decomposition of nitrous acid by passing its vapour through an ignited earthen tube is much more effectual. Dephlogisticated air and phlogisticated acid vapour are very abundantly † produced. The phlogisticated acid being again.

* See Priestley in Phil. Transactions, vol. lxxix. † Ibid.

subjected to the same operation, did not afford any more vital air, but passed nearly unchanged, excepting that a small portion was obtained towards the end, which probably arose from some nitrous acid which had escaped the action of the heat in the former process. Nitrous air is not changed by transmission through an ignited glass or earthen tube.

When the electric spark is repeatedly taken through nitrous air, in the same manner as in Mr. Cavendish's experiment for producing nitrous acid, a similar effect takes place. Nitrous acid is produced, and a residue of about half the original bulk is left, which consists of phlogisticated air; a proof that nitrous air consists of the acid not sufficiently saturated with vital air, or, which is the same thing, containing a surplus of phlogisticated air. The fact is worthy of the most attentive investigation of philosophers, that electricity should produce an effect so opposite to that of heat. This last power tends to disunite the principles of nitrous acid, whereas electricity renders their combination more intimate.

The nitrous acid is decomposed by heating together with different earths and metallic calces. The decomposition is, no doubt, greatly assisted by the fixed nature of these substances, which detain the acid, and by that means cause it to undergo a greater heat than it would else have been subjected to. When common nitre is exposed to a strong heat, it melts, and becomes red hot, and the volatile product is found to consist of fuming nitrous acid, a large quantity of vital air, and some phlogisticated air, the alkali remaining behind somewhat altered by a portion of the earth of the retort, which it dissolves. Various chemists differ in their accounts of the results of this experiment; which, indeed, may naturally be expected when we attend to the extreme difficulty of ascertaining the weights of aerial products, as well as the fixed residues, and at the same time consider that the quantity of nitrous acid decomposed at this elevated temperature, must in all probability differ according to the greater or less degree of heat; in the same manner as happens in the operations at lower temperatures. From these circumstances, it becomes a task of considerable difficulty to determine the intermediate steps of this operation.

The foregoing effects tend to explain what happens when nitrous acid is decomposed, in consequence of the superior elective attraction of its component parts to other substances. As the adhesion of these parts to each other in the full state of saturation which forms nitrous acid, is by no means strong; this acid acts upon almost every combustible substance, and produces effects in them, which are of the same nature as those which take place when vital air is absorbed in the act of combustion. In these operations with the nitrous acid, its vital air unites with the combustible body, while the remaining acid becomes fuming, and assumes the various colours which attend its phlogistication or defect of vital air, at the same time that it emits nitrous air with ebullition. The effects of the combination of vital air or combustion are, either calcination or acidification, according to the nature of the substances respectively; and the aerial fluid which flies off, being either nitrous air, dephlogisticated nitrous air, or phlogisticated air, it will be proper to speak in this place of the two first. For the latter, *see* AIR PHLOGISTICATED. *See, likewise*, ACID.

Nitrous air is a transparent, permanently elastic fluid, which may be received over water, as that fluid does not imbibe more than $\frac{1}{10}$ of its bulk of the air. Nitrous air thus imbibed is not found to have suffered any change in its properties, if it be immediately expelled by heat. When the nitrous air is less in quantity than is sufficient fully to saturate the water, the residue which is unabsorbed

forbed is found to be phlogificated air. The nitrous acid itself, when volatilized by heat, appears to be capable of retaining its elastic state, but can scarcely be operated upon, because of its action upon, or disposition to combine with, every fluid which can be used to confine it.

The vitriolic acid absorbs nitrous air, and assumes a purple colour. The marine acid imbibes it, and becomes blue. Pale nitrous acid absorbs it in large quantities, and the colour of the acid changes first at the surface, and then gradually through the whole of the liquid. The successions of colour are, yellow, deep orange, green, and, lastly, blue, according to the quantities of nitrous air absorbed. These changes are of the same nature as any others, which may increase the proportion of phlogificated air in the composition of the acid. The deep coloured or phlogificated acid is more volatile than the pale, and has a greater specific gravity.

But the most distinguishing and characteristic property of nitrous air, is the readiness with which it becomes converted into nitrous acid, whenever it is brought in contact with vital air. In this situation it forms red fumes, which are the nitrous acid itself in the act of condensation. This property of nitrous air, by which it combines with, and takes vital air from, the atmosphere, or from any other respirable air, has been applied by Dr. Priestley, as a test of the purity, or respirability of aerial fluids; for the manner of doing which, *see AIR ATMOSPHERICAL*. It is scarcely necessary to repeat, that the red fumes of phlogificated nitrous acid consist of nitrous air in the act of uniting with the air of the atmosphere. The conversion of nitrous air into nitrous acid, by the electric spark, has already been mentioned in the present article.

According to Mr. Lavoisier's experiments, the component parts of nitrous air consist of about twenty-one parts, by measure, of phlogificated air, with forty-three of vital air; and thirty-six parts more of vital air are required to change this nitrous air into nitrous acid. Mr. Cavendish's experiments shew that one part, by measure, of phlogificated air requires two of vital air, to convert it into nitrous acid. This is a considerably greater proportion of the former: but Mr. Lavoisier reconciles the two results, by supposing that the nitrous acid of Mr. Cavendish was of the kind called phlogificated.

When nitrous air is exposed to iron filings and brimstone, liver of sulphur, or iron alone, it is gradually diminished, and converted into dephlogificated nitrous air. The peculiar property of this air is, that it is fatal to animal life, though a candle will burn in it with an enlarged flame, rather better than in common air. The presence of water appears to be necessary in the production of this singular fluid. It is also obtained during the solution of tin, and of zinc, in the nitrous acid, or by adding iron to the nitrous solution of copper. The constitution of dephlogificated nitrous air has not yet been well explained, and it is even a question whether this air be more or less dephlogificated than nitrous air itself. From its maintaining flame, there can be no doubt but that it contains vital air; but this is no proof that the quantity is greater than in nitrous air, but merely that the constitution of this air is such, as to give out its vital air to combustible substances at the temperature of ignition, though at the lower temperature of animal life its presence may not be exhibited. Dephlogificated nitrous air appears, indeed, to contain both nitrous air and vital air, and to participate of the properties of both; but why the two should not unite, and form nitrous acid, remains a difficulty. May not the presence of inflammable air be one leading cause of this? When nitrous air is exposed, together with moisture, to iron, the iron is calcined, and, no doubt, emits inflammable

flammable air, whether that air be taken to arise from the iron itself, or the water. If, therefore, in this experiment, the quantity of inflammable air which escapes, should unite with the nitrous air, it may form a triple combination, consisting of the very fluid called dephlogisticated nitrous air, which should, it seems, possess the property of more readily giving out its vital air to a combustible substance, because of the disposition which the other component parts, namely, inflammable air and phlogisticated air, have to unite, and form volatile alkali; although it may easily be imagined, that the original compound might not emit its vital air with sufficient facility to support animal life, or, if it did, that the simultaneous production of alkaline air might be attended with noxious effects.

Mr. Milner, whose curious experiments of the production of nitrous vapours by means of volatile alkali and vital air at a red heat, have been already adverted to, decomposes the nitrous acid, by causing its vapour to pass through an ignited gun-barrel, crammed full of iron filings. When the transition of the nitrous vapour is rapid, in comparison to the ignited surface of the iron, which is exposed to calcination by the vital air of the acid, the product consists of nitrous air and phlogisticated air: when the transition is less rapid (at a rate not easily produced and maintained), the product consists of phlogisticated and nitrous airs, with a mixture of dephlogisticated nitrous air: and lastly, if the ebullition of the acid which supplies the vapour be very slow, and a sufficient quantity of the iron tube be well heated, the decomposition is almost complete, and the product consists almost entirely of phlogisticated air. It appears, therefore, that the nitrous acid in the order of its decomposition becomes first nitrous air, then dephlogisticated nitrous air, and, lastly, phlogisticated air; accordingly as it is deprived of a greater quantity of vital air, and probably with the addition of some inflammable air in the middle stage of its conversion.

The action of nitrous acid upon combustible substances, is attended with a great variety of curious and instructive phenomena. With the metals it usually affords nitrous air, which, in its transition through the superincumbent acid, produces the various changes of colour already noted. This is elegantly shewn in the solution of mercury in the nitrous acid. The metal is calcined by the vital air of that part of the acid which was decomposed; while the remaining acid dissolves the calx. Such metals as are more effectually and rapidly calcined, produce a more perfect decomposition of the acid. None are more particularly calculated to shew these effects than tin. According to the strength and quantity of the acid, this metal is calcined or dissolved, with the emission of nitrous air, of dephlogisticated nitrous air, or without the escape of any elastic fluid, at the same time that volatile alkali is formed in the solution. In these cases, the effects seem to differ, according to the extrication and quantity of inflammable air. When the acid is diluted with half its weight of water, and the tin at the beginning of the process is not much calcined, the quantity of inflammable air extricated (either from the tin, as phlogiston, or from the water, by decomposition) is inconsiderable, and nitrous air escapes. As the operation proceeds, the quantity of inflammable air becomes more considerable, and the triple combination of phlogisticated, vital, and inflammable airs, that is to say, the fluid called dephlogisticated nitrous air, is thrown off. But when, by the action of strong acid, the tin is rapidly calcined, without the presence of much water, either to supply inflammable air, or latent heat to maintain the elastic state, the whole of the vital air, which is taken from the nitrous acid, enters into the calx of tin; while the whole of the inflammable air, which would else have

have been set at liberty, combines with the phlogificated air of the decomposed air, and by that means forms volatile alkali.

In the action of nitrous acid upon organized bodies, there are also a great number of remarkable effects which take place, both with regard to the elastic products and residues. When the nitrous acid is applied to the flesh, or other parts of animal substances, the elastic fluid, which is first and most plentifully disengaged, is phlogificated air. In this experiment, the phlogificated air may come from the animal substance, or the acid, or both; since both contain it. It appears, however, to be much more probable, that the whole comes from the animal substances. For it is afforded by the application of a very weak nitrous acid, at so low a temperature as 65° or 70° ; both which circumstances do not appear to indicate a decomposition of the acid. The nitrous acid, after its action, saturates as large a quantity of alkali as before. The quantity of phlogificated air is in proportion to the quantity of volatile alkali which the animal substance made use of affords by distillation; and it is known that the quantity of phlogificated air contained in any animal substance must be in this proportion. And, lastly, at a greater heat, after the phlogificated air has come over, there is a disengagement of nitrous air, which indicates a less complete decomposition of the acid than that which would have afforded phlogificated air: and it is not consonant with other chemical facts, that the complete decomposition of the acid should happen at a lower heat, than the partial decomposition which succeeds it.

The nitrous acid has a very considerable action upon vegetable substances, which it corrodes, or dissolves, at the same time that much nitrous air is disengaged, together with fixed air. The phenomena are various, according to the nature of the several substances. In many instances, the residue consists of an acid of a different kind from the nitrous, which, according to the proportions of the materials, and management of the process, is either acid of sugar, or vinegar; or when the destruction of the vegetable substance is most complete, fixed air is the product. *See ACID OF SUGAR.*

In general, when the nitrous acid is mixed with any liquid inflammable matter, it requires to be diluted, and the quantity of this last should be very small, and just sufficient to cover the surface of the acid; otherwise, though the mixture may exhibit no alarming appearance at first, it will in a little time become very black, beginning at the surface; the vial will then be filled with red fumes, the air will be generated in a prodigious torrent, and unless the tube through which it is transmitted be sufficiently wide, and the vessel in which the mixture is made be very strong, the whole will be exploded with great violence.

When the nitrous acid is mixed with spirit of wine, as in the making of nitrous ether, for the management of which process, *see ETHER NITROUS*, the air produced is very considerable in quantity, and burns with a blue or greenish flame, very much resembling that which is produced by a mixture of about $\frac{1}{4}$ of inflammable air, $\frac{3}{4}$ of nitrous air, so that probably it consists of both. When a very small quantity of spirit of wine * was poured upon a quantity of diluted spirit of nitre in a glass vial, with a ground stopper and tube, a great quantity of air was presently produced. When a candle was dipped in this air, it was extinguished; but in going out was surrounded with a slight blue or green flame, though hardly more than is perceived in nitrous air. About one half of this produce of air was

* Priestley methodised, III. 70.

fixed air, as appeared by its precipitating lime water, and the remainder was strong nitrous air.

With oil of turpentine, the effervescence is very rapid, and sudden, if strong nitrous acid be used; but a great quantity of air is easily produced by diluting the strong acid with an equal quantity of water, and cautiously heating it, lest an explosion should take place, in consequence of the air being too rapidly extricated. In some instances, when the production of air is rapid, it is of that kind which is distinguished by the name of dephlogisticated nitrous air. In general, the air consists of nitrous and fixed air in considerable quantities, together with a smaller proportion of inflammable, and some dephlogisticated nitrous air, together with nitrous acid in vapour.

Dr. Priestley did not find that the air produced by applying nitrous acid to the other essential oils, was remarkably different from that produced with spirit of turpentine.

Ether, both vitriolic and nitrous, heated in nitrous acid, yields the same kind of air as the essential oils, or spirit of wine; namely, partly fixed air, and partly dephlogisticated nitrous air. Equal caution is also necessary in conducting this process; for the phenomena attending it are in the highest degree dangerous. For this reason, it is proper to use only a very small quantity of the ether, which is to be poured on the spirit of nitre, this last being previously much diluted.

Olive oil, and also tallow, produce nearly the same kinds of air as the essential oils. The gums, likewise, exhibit nearly the same phenomena. Camphor affords nitrous air, by the application of a considerable degree of heat.

One of the earliest known facts of spontaneous inflammation, is that produced by the affusion of the nitrous acid upon oil. All the oils obtained by distillation from vegetables, and known by the name of essential oils, are proper for this experiment. An ounce of the oil intended to be set on fire must be placed in a shallow vessel, and a bottle, containing an ounce of the most concentrated nitrous acid, must be fastened at the end of a pole, that the operator may be sufficiently distant from the inflammation. Two thirds of the acid being poured on the oil, makes a considerable ebullition; the oil growing black and thick, and sometimes taking fire. But if this last circumstance does not happen in five or six seconds, the remainder of the acid must be poured when the mixture appears most dry and black, and then the inflammation seldom fails to take place.

Fat oils may also be inflamed, if equal parts of the nitrous and vitriolic acids be first poured on them, and, when the ebullition is at the greatest, a portion of nitrous acid be poured on the dryest part.

Strong nitrous acid, of the specific gravity of 1.54, being added to the powder of charcoal, or lamp black*, recently made very dry, takes fire, and detonates. There is some uncertainty in this experiment; but the method which is said to insure success, is to put the dry powder into a very dry retort, and pour the acid upon the side of the glass, so that it may not fall upon the powder, but flow beneath it.

The production of heat in these phenomena, which no doubt arises from the action excited between the combustible body and the vital air of the acid, has not yet been explained in an adequate manner from experiments tending to shew how the capacities of the bodies for heat are changed by the process.

There is scarcely any modern improvement in chemical operations of greater va-

* Proust, in the *Journal de Medecine* for July 1788.

lue and importance in the examination of a great variety of bodies, than the application of nitrous acid, which, by repeated abstraction, converts them into several acids. This is effected by the readiness with which the nitrous acid is decomposed, and supplies the requisite quantity of vital air to the respective acidifiable bases. See the *Acids* of arsenic, of phosphorus, of vitriol; also, sulphur, wool.

Many of the opinions respecting the component parts of nitrous acid, which were adopted or maintained at the commencement of the modern discoveries on air, do not appear at present to be insisted upon; and it is now generally admitted, that acids are formed by the union of vital air with combustible matter. In the present case, it is sufficiently proved, by Mr. Cavendish's experiments, that nitrous acid consists of vital and phlogisticated airs; and the differences of opinion, in other respects, are chiefly grounded upon considerations which relate to the supposed composition of the phlogisticated air. The negative qualities of this last substance are found in the residues of most aerial fluids, which have been diminished or absorbed in chemical processes. And from this fact, combined with the supposition, that all the fluids, distinguished by the name of phlogisticated air, are one and the same substance, it has been inferred that the several fluids are convertible into phlogisticated air, which is consequently taken to be related to them in various ways, according to theories, which being for the most part gratuitous, need not be here enlarged upon. The chief inference of this kind, is that which supposes phlogisticated air to be a modification of inflammable air, which is supposed to be combined with a certain due proportion of vital air: so that it consists of vital air, phlogisticated or combined with the inflammable principle. According to this theory*, a larger proportion of the vital air will produce the common air of the atmosphere, and still greater successive additions of vital air will form nitrous air, the aeri-form nitrous acid, the fuming nitrous acid, and the pale nitrous acid. The sum of this opinion consists, therefore, in substituting inflammable air in the place of phlogisticated air; and this substitution is defended chiefly from the fact, that when water is produced by the combustion of vital and inflammable air, there are few cases in which there is not a production of nitrous acid. The late papers of Dr. Priestley, in the *Philosophical Transactions* (wherein the great quantity of water naturally held in solution by the two airs, and the volatility of the nitrous acid, which is usually of the sort called highly phlogisticated, and is not easily condensable in glass vessels, for want of a base to combine with, are particularly attended to), render it highly probable, that the supposed composition of water is a fallacy, and likewise, that the nitrous acid is composed of the two airs in question. But, on the other hand, it is stated that this nitrous acid may probably arise from a combination of the vital air with a portion of the phlogisticated air, from which that fluid is never absolutely free; though this is denied by Dr. Priestley, who did not find that the production of nitrous acid was greater when a larger proportion of phlogisticated air was added to the mixture.

The properties and habitudes of nitrous acid are explained in almost every article of chemical operation.

ACID, PHOSPHORIC. The base of this acid, or the acid itself, abounds in the mineral, vegetable, and animal kingdoms. In the mineral kingdom it is found in combination with lead, in the green lead ore; with iron, in the bog ores which afford cold short iron; and more especially with calcareous earth in several kinds

* Of Kier. See the exposition at large, in the article *Acid nitrous*, of his valuable *Chemical Dictionary*.

of stone. Whole mountains in the province of Estramadura * in Spain are composed of this combination of phosphoric acid and lime. Mr. Bowles affirms that the stone is whitish, and tasteless, and affords a blue flame without smell when thrown upon burning coals. Mr. Proust describes it as a dense stone, not hard enough to strike fire with steel; and says that it is found in strata, which always lie horizontally upon quartz, and which are intersected with veins of quartz. When this stone is scattered upon burning coals, it does not decrepitate, but burns with a beautiful green light, which lasts a considerable time. It melts into a white enamel by the blow pipe; is soluble with heat, and some effervescence in the nitrous acid, and forms selenite with the vitriolic acid, while the phosphoric acid is set at liberty in the fluid.

The vegetable kingdom abounds with phosphorus, or its acid. Various seeds, potatoes, agaric, foot, woods, and charcoal afford phosphoric acid, by abstracting the nitrous acid from them, and lixiviating the residue. The lixivium contains the phosphoric acid, which may either be saturated with lime by the addition of lime water, in which case it forms a solid compound, or it may be tried by examination of its leading properties by other chemical methods.

In the animal kingdom it is found in almost every part of the bodies of animals, which are not considerably volatile. There is not, in all probability, any part of these organized beings which is free from it. It has been obtained from blood, flesh, both of land and water animals; from cheese; and it exists in large quantities in bones, combined with calcareous earth. Urine contains it, not only in a dissolved state, but also combined with volatile alkali, with mineral alkali, and with lime. It was by the evaporation and distillation of this excrementitious fluid with charcoal that phosphorus was first made; the charcoal decomposing the dissolved acid, and the volatile alkaline salt. See PHOSPHORUS. But it is more cheaply obtained by the process of Scheele, from bones, by the application of an acid to their earthy residue, after calcination.

In this process the vitriolic acid appears to be the most convenient, because it forms a nearly insoluble compound with the lime of the bones. Bones of beef, mutton, or veal, being calcined to whiteness in an open fire, lose almost half of their weight. This must be pounded, and sifted, or the trouble may be spared by buying the powder that is sold to make cupels for the assayers, and is, in fact, the powder of burned bones ready sifted. To three pounds of the powder, there may be added about two pounds of concentrated vitriolic acid. Four or five pounds of water must be afterwards added to assist the action of the acid; and during the whole process the operator must remember to place himself and his vessels so that the fumes may be blown from him. The whole may be then left on a gentle sand bath for twelve hours or more, taking care to supply the loss of water, which happens by evaporation. The next day a large quantity of water must be added, the whole strained through a sieve, and the residual matter, which is selenite, must beedulcorated by repeated affusions of hot water, till it passes tasteless. The waters contain phosphoric acid nearly free from lime, and by evaporation, first in glazed earthen, and then in glass vessels, afford the acid in a concentrated state, which by the force of a strong heat in a crucible, may be made to acquire the form of a transparent consistent glass, though indeed it is usually of a milky, opaque appearance.

For making phosphorus, it is not necessary to evaporate the water farther than

* Annales de Chimie, I. 196. Also, Kier's Dictionary, and the authors by him quoted.

to bring it to the consistence of syrup; and the small portion of lime it contains is not an impediment worth the trouble of removing, as it affects the produce very little. But when the acid is required in a purer state, it is proper to add a quantity of mild volatile alkali, which, by double elective attraction, precipitates the lime which was held in solution by the phosphoric acid: that is to say, the volatile alkali unites with the phosphoric acid, while the fixed air unites with the lime, and causes it to fall down in the form of the indissoluble compound, chalk. The fluid being thus evaporated, affords a crystallized ammoniacal salt, which may be melted in a silver vessel, as the acid acts upon glass or earthen vessels. The volatile alkali is driven off by the heat, and the acid acquires the form of a compact glass as transparent as rock crystal, acid to the taste, soluble in water, and deliquescent in the air.

This acid is very pure, but nevertheless may contain a small quantity of mineral alkali, originally existing in the bones, and not capable of being taken away by this process, ingenious as it is. The only unequivocal method of obtaining a pure acid appears to consist in first converting it into phosphorus by distillation of the materials with charcoal, and then converting it again into acid by combustion, or some other equivalent process.

If a number of sticks of phosphorus be placed upright in a glass funnel, a piece of glass being previously put into the neck of the funnel to prevent their falling through; and if this funnel be then inserted in the neck of a bottle, containing distilled water, the phosphorus will be gradually decomposed by a slow combustion, provided it be exposed to a temperature not much lower than 60°. The phosphoric acid will gradually pass through the funnel into the water. The acid obtained, contains a portion of phosphorus; but by exposure to the air, this also becomes converted into acid: or the superfluous portion of phosphorus may be burned, by causing the fluid to boil. This may be concentrated by evaporation of the water if required, and may, like every other solution of this acid, be reduced to the concrete or glacial form, by a sufficient degree of heat. This glacial acid is deliquescent, though it is said, that a stronger heat will deprive it of solubility, and acidity; most probably in consequence of a solution of part of the earth of the retort or crucible.

Phosphorus may also be converted into the acid state by treating it with nitrous acid. In this operation, a tubulated retort, with a ground stopper, must be half filled with nitrous acid, and a gentle heat applied. A small piece of phosphorus being then introduced through the tube, will be dissolved with effervescence, produced by the escape of a large quantity of nitrous air. The addition of phosphorus must be continued until the last piece remains undissolved. The fire being then raised to drive over the remainder of the nitrous acid, the phosphoric acid will be found in the retort, partly in the concrete, and partly in the liquid form.

Vitriolic acid produces nearly the same effect as the nitrous; a large quantity of phlogisticated or sulphureous vitriolic acid flying off. But as it requires a stronger heat to drive off the last portions of this acid, it is not so well adapted to the purpose.

When phosphorus is burned by a strong heat, sufficient to cause it to flame rapidly, it is almost perfectly converted into dry acid, some of which is thrown up by the force of the combustion, and the rest remains upon the supporter.

This substance has also been acidified by the direct application of vital air passed through hot water, in which the phosphorus was liquefied or fused.

When a stick of phosphorus is plunged in the solutions of gold, silver, copper, and

and other metals, the phosphorus gradually receives vital air from the metallic calx, and becomes acidified, while the metal resumes its reguline state, and forms a brilliant sheath of revived metal surrounding the remaining phosphorus.

The general characters of phosphoric acid, are, 1. It is soluble in water in all proportions, producing a specific gravity, which increases as the quantity of acid is greater, but does not exceed 2687:1000, which is that of the glacial acid. 2. It produces heat when mixed with water, though not very considerable. 3. It has no smell when pure, and its taste is sour, but not corrosive. 4. When perfectly dry, it sublimes in close vessels; but loses this property by the addition of water, in which circumstance it greatly differs from the acid of borax, which is fixed when dry, but rises by the help of water. 5. When considerably diluted with water, and evaporated, the aqueous vapor carries up a small portion of the acid. 6. With charcoal or inflammable matter, in a strong heat, it loses its acidity, and becomes converted into phosphorus.

When liquid phosphorus is heated, no part of the vapour retains the aerial or permanently elastic form; neither does it afford air by boiling with mercury, or even ardent spirit. But it readily dissolves iron, with the assistance of a little heat, with which it affords a strong inflammable air. But the effect of adding the acid of phosphorus to minium is highly singular, and by no means easy to be explained. When all the air has been expelled from minium, which mere heat can drive out, this substance yields vital air when heated with nitrous air, but no air at all with the vitriolic or marine acids. The phosphoric acid (produced by deliquescence or slow combustion) mixed with this minium, with little or no sensible heat; but the mixture exposed to the flame of a candle yielded air very plentifully, and it was very turbid. It did not precipitate lime water over which it was received, except in the smallest degree. Neither was it affected by nitrous air, nor did it affect common air; but was strongly inflammable, burning with a bright white flame, and the smell of the air was the same with that of the strong smell of phosphorus. The calx or massicot* became of a darkish grey colour, or nearly black, by this process.

The phosphoric acid does not appear to act upon siliceous earth in the humid way, though it has been observed to corrode glass when hot. In the dry way, it acts upon all the earths. With calcareous earth, in the humid way, it forms a gummy mass, containing some crystals, but the greatest part of the mass takes a pulverulent form, and subsides. This compound is scarcely soluble in water, unless by virtue of an excess of acid. It does not differ from the white earth of calcined bones. Phosphoric acid, added to a marine solution of ponderous earth, seizes this salt, and falls with it to the bottom in an insoluble precipitate. With magnesia, it likewise forms a crystallizable compound of very difficult solubility. It also unites with clay or earth of alum, forming an insoluble saline powder, and a fluid which, by evaporation, yields a gritty powder, and a thick gummy solution, convertible by heat into a transparent glass.

This acid, when in combination with the vegetable alkali, forms a very soluble salt, which is much more soluble in hot than in cold water, and may be obtained in crystals, either by cooling or evaporation. It decrepitates in the fire, and afterwards melts without decomposition. The combination of mineral alkali with phosphoric acid, forms a gummy fluid not easily crystallized, unless there be a small excess of alkali, in which case it effloresces by exposure to a dry air. The taste of this salt not being nauseous, but considerably resembling that of common salt,

* Priestley, ed. 1790. III. 293.

it has lately been introduced into medical practice as a cathartic. When urine is evaporated, this salt is among its products; and as it is not decomposable by the dry way with charcoal, it was at first considered as a peculiar substance, and distinguished by the name of the perlate salt or acid.

The volatile alkali forms, with the acid of phosphorus, a crystallizable salt, which when obtained in an impure state from urine, by evaporation, has been called microcosmic salt, and is of great use in experimental assays by the blow-pipe. It is more soluble in hot than in cold water, and crystallizes most easily when the alkali is rather in excess. A gentle heat decomposes it, when dissolved in water, and causes part of its alkali to fly off, so that it cannot easily be purified by crystallization, unless by solution, and cooling in closed vessels.

Phosphoric acid does not act in the humid way upon gold, silver, platina, or mercury; but it formed a purple scoria when fused with gold leaf. It scarcely acts on copper, unless, perhaps, by the assistance of the air in process of time. It corrodes tin, at the same time that it emits an offensive smell. The calx of this metal is in some degree soluble in it, and is so far changed as to be rendered very fusible. Lead is a little corroded by the phosphoric acid. Neither mercury nor its calces are soluble in it; but it changes red precipitate to a yellow and white colour, and lastly, by long digestion, to black. The white calx of arsenic is completely dissolved, but not the regulus. Zinc, likewise, is perfectly dissolved, and affords by evaporation a gummy mass, which runs by fusion into a transparent glass. Regulus of antimony is dissolved in a small proportion, as are also bismuth and its calx, and the calx of nickel. With regulus of manganese it forms a white solution, and a red solution with the calx, which, however, becomes white on exposure to the air.

The action of phosphoric acid in the dry way is much more powerful. With some of the most calcinable metals, especially with tin, lead, iron, and zinc, it becomes partly converted into phosphorus; and with most of them this conversion takes place if charcoal be present, in which case the phosphorus combines with the metal. *See PHOSPHORUS.* When the phosphoric acid is combined with iron, its effects are such as deserve the most particular attention. In the humid way, it is readily dissolved, with effervescence, and the disengagement of inflammable air; and the solution affords permanent crystals, provided the acid be rather in excess; but if the acid be more abundant, the product is a dry adhesive mass, which falls to the bottom, and is insoluble in water, but soluble in ardent spirit, or in the diluted vitriolic acid. It has already been mentioned that the compound of phosphoric acid and iron in the bog ores, renders the metal cold-short: for the particulars of which the article IRON may be consulted.

Though the phosphoric acid is scarcely corrosive, yet, when concentrated, it acts upon oils, which it discolours, and at length blackens, producing heat, and a strong smell like that of ether and oil of turpentine; but does not form a true acid soap. It has most effect on essential oils, less on drying oils, and least of all on fat oils. Spirit of wine and phosphoric acid have a weak action on each other. Some heat is excited by this mixture, and the product which comes over in distillation of the mixture is strongly acid, of a pungent arsenical smell, inflammable with smoke, miscible in all proportions with water, precipitating silver and mercury from their solutions, but not gold; and although not an ether, yet it seems to be an approximation to that kind of combination*.

* *Chimie de Dijon*, III. 338.

The theory of the phosphoric acid, as far as relates to its component parts, is perfectly similar to that of the other acids, which have hitherto been successfully examined. Phosphorus is the combustible substance, which by combustion absorbs vital air, and becomes converted into an acid : and on this occasion, the two theories of chemistry stand precisely on the same ground as has been explained in the general article on ACIDS. The phosphorus, considered as a simple body, unites with the vital air, likewise considered as simple ; or else, by a greater refinement of explanation, the phosphorus parts with phlogiston, while its acidifiable basis unites with vital air, and forms acid ; or, lastly, if the vital air itself be supposed to be a compound, the explanation will become still less simple, and will vary according to the gratuitous positions which may be introduced into the theory.

ACID OF PRUSSIAN BLUE. The habitudes of the colouring matter of Prussian blue denote it to be an acid. *See PRUSSIAN BLUE.* If the Prussian blue be boiled with an alkali, the colouring matter immediately quits the iron, to combine with the salt, and from this alkali the colouring matter or acid may be extricated by boiling in a retort with diluted acid of vitriol. The colouring matter comes over in the form of an inflammable air, which will be absorbed by water placed for that purpose in the receiver. As a portion of vitriolic acid, likewise, comes over, a second distillation is necessary to be made, with the addition of chalk. The vitriolic acid, by this means, forming selenite, is detained ; while the Prussian acid passes over totally, before one fourth of the water is distilled off.

The colouring matter of Prussian blue is not only seized by the fixed alkalis, but likewise by the volatile alkali, by lime, by magnesia, and by ponderous earth ; with which it forms peculiar compounds, capable of precipitating Prussian blue, by double affinity, from the solutions of iron in acids. Various metals, likewise, combine with it. Alkalis, or lime, combined with the Prussian acid, are used as tests to ascertain the presence and quantity of iron in solutions. But all the alkaline or earthy combinations, produced by boiling those substances with Prussian blue, contain iron, which falls down in the form of the blue precipitate when an acid is added. For this reason, they cannot be used in accurate experiments, unless a previous trial has been made of the quantity a known proportion of the proof liquor is capable of precipitating.

If the dephlogisticated or aerated marine acid be mixed with the Prussian acid, the former resumes the state of common marine acid ; while the latter acquires a much stronger smell, and appears to be more volatile. In this situation, it does not form Prussian blue with the solutions of iron ; but affords a green precipitate, which becomes blue by exposure to the light, or by the addition of volatile vitriolic acid.

If martial vitriol be added to the dephlogisticated or aerated marine acid, and a solution of Prussian alkali be poured in, the green precipitate which is formed is again dissolved ; but it may be precipitated of a blue colour by the addition of volatile vitriolic acid, or martial vitriol, or iron alone.

In the instances last mentioned, we may perceive that the effects depend on the dephlogistication or addition of vital air, to the Prussian acid, accordingly as we adopt the ancient or the modern theory. The green precipitate, which may be considered either as dephlogisticated Prussian blue, or as Prussian blue combined with vital air, becomes common Prussian blue by the action of light, which, as we have frequently had occasion to remark, operates, in many instances, in a manner contrary to that of combustion ; that is to say, it either adds phlogiston, or expels vital air, or does both. By this action, therefore, the Prussian blue returns to its original state. The addition of volatile vitriolic acid must produce a like effect ; for this acid is phlo-

gified according to the old theory, or is deficient in vital air according to the new: it is therefore disposed either to phlogificate the green precipitate, or to attract vital air from it; which is all that it requires to convert it into common Prussian blue. The same theories manifestly apply to the green precipitate, which is redissolved: for in whatever state of combination it may be supposed to remain, as to the order or arrangement of the principles which are united in the fluid, the addition of volatile vitriolic acid, or common vitriol, or iron in the metallic state, will impart phlogiston, or attract vital air; the absence of the one, or the redundancy of the other of which, is supposed, according to the respective theories, to cause the difference between it and Prussian blue.

If the Prussian acid be impregnated more strongly with the dephlogificated or aerated marine acid, and then exposed to the action of light, it assumes new properties. It no longer combines with iron precipitated from its solutions; its smell is entirely different from that which it before possessed, and now resembles an aromatic oil, the greatest part of it separating from the water, at the bottom of which it flows in the form of an oil. This fluid, however, is not inflammable. By a gentle heat it rises in the form of a vapour, not soluble in water: and in time it assumes the form of small crystals. Prussian acid cannot be restored after it has undergone these changes.—Their theory is not known.

Various experiments have been made to discover the component parts of the Prussian acid. If equal parts of pulverized charcoal and vegetable alkali be made red hot for a quarter of an hour in a crucible, and some sal ammoniac in small pieces be then briskly stirred down into the mass, the ammoniacal vapours will soon cease. The ignited matter being then thrown into water, affords a lixivium equal to the best which is made with blood. From these, and other experiments, it was concluded, that its component parts are fixed air, volatile alkali, and the principle of inflammability, or phlogiston. Later experiments appear to have decided the question somewhat more accurately. When the acid has been converted, by means of the dephlogificated or aerated marine acid, into that state which affords a green precipitate with iron, it emits alkaline air upon the addition of lime, or a pure alkali. If the lime, or alkali, be afterwards saturated by the addition of some other acid, the Prussian acid is not disengaged, or restored, but is no where found; hence it follows, that the alkaline air was one of the principles of the Prussian acid, which is destroyed: and as the lime or alkali used in this decomposition is found to be in a mild state, that is to say, combined with fixed air, though it did not contain that substance before; it is clear that the other principle of the Prussian acid is fixed air. The common Prussian acid consists, therefore, of volatile alkali, united with the base of fixed air, or that substance which, in combination with vital air, forms the acid called fixed air. When the Prussian acid receives vital air, and is converted into the state proper to afford the green precipitate; it then appears to consist of the same principles as the mild or concrete volatile alkali, though probably in a different order of combination, and this order seems to be deranged by the addition of the lime, or the fixed alkali, which attracts those principles that form fixed air, at the same time that the principles which form volatile alkali fly off in the elastic state.

The component parts of Prussian acid will consequently be phlogificated air, inflammable air, and fixed air, or its base; all which are afforded by animal substances; but they do not form this peculiar combination in any case yet known, excepting that in which an alkali is present, when those substances are decomposed by fire.

ACID OF SORREL. This acid is obtained from the salt of sorrel, and does
not

not in any respect differ from the acid of fugar, or saccharine acid. The salt of forrel is a crystallized salt; so denominated, because it is obtained from the wood forrel, or oxalis acetosella of Linnæus, for the purposes of commerce; though it may be obtained from some other plants. It is in white crystals, whose figure has not been well determined, on account of their minuteness. When it is exposed to distillation in a retort, the acid is partly decomposed; a considerable quantity of acid phlegm comes over, which is without smell or colour, and consists of the acid itself, scarcely altered; and the residue affords vegetable alkali, amounting to somewhat more than one third of the weight of the salt. Exposure to air does not alter the salt of forrel. It is very sparingly soluble in cold water: but boiling water may take up one sixth, or more, of its weight; the quantity varying according to the state and purity of the salt, which seems to vary in different specimens.

Salt of forrel acts upon various substances without decomposition. With ponderous earth, magnesia, vegetable alkali, and volatile alkali, it forms triple salts. Lime decomposes it, by seizing the whole of the acid, and disengaging the alkali. The attraction of this acid for lime is so strong, that it cannot be disengaged from it by any other acid: another process is therefore necessary to be used for obtaining it. With this intention, the superabundant acid is to be saturated with volatile alkali; and into this solution must be poured a solution of ponderous earth in the nitrous acid. The last mentioned acid combines with the alkalis, forming nitrous ammoniac and common nitre, both which remain in solution; while the ponderous earth combining with the acid of forrel, forms an insoluble compound, which falls to the bottom. This precipitate, after being well washed, may be decomposed by the addition of vitriolic acid, which seizes the earth, and likewise forms an insoluble combination, while the acid is set at liberty. After decantation of the clear liquid, it must be assayed by pouring into it a little at a time of the boiling hot solution of ponderous earth in the acid of forrel. If there be any excess of vitriolic acid, a precipitate will be formed by its union with the ponderous earth. A due evaporation and cooling of this liquor afford the acid of forrel or saccharine acid, in prismatic four-sided crystals or square plates.

ACID OF SUGAR, or SACCHARINE ACID. This acid is so denominated, because it was first obtained from fugar when submitted to chemical examination. The process of Bergman is as follows: Three ounces of strong nitrous acid, whose specific gravity was nearly 1.567, were mixed in a tubulated retort with one ounce of the finest sugar in powder. Much nitrous air escaped in red fumes, formed by combination with the vital air of the atmosphere. A receiver was then adapted, and the liquor gently boiled. As soon as the mixture had acquired a dark brown colour, three additional ounces of nitrous acid were added, and the boiling was continued until the coloured and fuming acid had entirely disappeared. The liquor being then poured out, afforded small prismatic crystals by cooling, which weighed 109 grains, and are the acid of fugar. The remaining lixivium being again treated in the same manner, with two ounces of nitrous acid afforded an additional portion, consisting of forty-three grains of acid of fugar, which separated by cooling; and the remaining glutinous liquor being treated at different times with small quantities of nitrous acid, amounting in the whole to two ounces, and evaporated to dryness, afforded a saline mass, brown, glutinous, and deliquescent, which, when perfectly dried, weighed half a dram: and, lastly, the whole was depurated by repeated solutions and crystallizations in water. In this way, with three parts of fugar and thirty of nitrous acid, the quantity of one part of acid of fugar is obtained.

It may be observed, that a weaker nitrous acid will answer the purpose nearly as well

well as the concentrated acid ; and that where it is not an object to collect the acid which comes over, there will be no need of any receiver or other apparatus, except a matrafs or Florence flask to perform the operation in a chimney where there is a proper draft of air to carry off the acid fumes.

It has been discovered, since the original experiments of Scheele and Bergman, that a variety of other substances afford the nitrous acid when treated in the above manner. Bergman procured it from honey, gum arabic, spirit of wine, and the calculus concretions in the kidneys and bladders of animals ; Scheele and Hermbstadt from sugar of milk. Scheele from a sweet matter contained in fat oils, and also from the uncrystallizable part of the juice of lemons. Hermbstadt from the acid of cherries, and the acid of tartar. Gottling from beech wood. Kohl from the residuum in the distillation of ardent spirits. Westrumb not only from the crystallized acids of currants, cherries, citrons, raspberries, but also from the saccharine matter of these fruits, and from the uncrystallizable parts of the acid juices. Hoffman from the juice of the common barberry ; and Berthollet from silk, hair, tendons, wool ; also from other animal substances, especially from the coagulum of blood, whites of eggs, and likewise from the amylaceous and glutinous parts of flour *.

Mr. Berthollet observes, that the quantity of the saccharine acid obtained by treating wool with nitrous acid was very considerable, having got above half its weight of saccharine acid ; whereas Bergman obtained only one third from the sugar employed. He mentions a difference which he observed between animal and vegetable substances thus treated with nitrous acid, namely, that the former yielded, besides volatile alkali, a large quantity of an oil, which the nitrous acid could not decompose ; whereas the oily parts of vegetables were totally destroyed by the action of this acid : and he remarks, that in this instance the glutinous part of flour resembled animal substances, whereas the amylaceous part of the flour retained its vegetable properties. He further remarks, that the quantity of saccharine acid furnished by vegetable matters is proportionable to their nutritive quality, and particularly that from cotton he could not obtain any sensible quantity.

These crystals of acid of sugar have an exceedingly pungent taste, but, when sufficiently diluted with water, their taste is agreeable. It converts all blue vegetable juices, except that of indigo, to a red. It expels fixed air from alkalis and earths, and consequently effervesces with them if they be in the mild state. Boiling distilled water dissolves its own weight of the crystals, though in a heat of sixty degrees it dissolves only half of that quantity. The solution at first appears a little turbid, but soon recovers a perfect transparency. The specific gravity of this last solution, when saturated, is 1.0593. The vapours which arise during the boiling of the former solution do not contain any acid, and the liquor as it cools gradually deposits a great quantity of crystals, many of which exhibit prisms diverging from a point.

These crystals of acid of sugar are soluble in other acids. Concentrated vitriolic acid seizes the oily matter and grows brown, and at length totally consumes the crystals, especially on boiling ; but when diluted, though it dissolves the crystals readily, yet it yields them up again, but in the form of needles, a change which this acid likewise produces with other salts. The nitrous acid readily takes up the acid of sugar, and upon boiling grows yellow. Upon cooling, the crystals are again separated, but generally irregular and less in quantity. If the solution be often repeated with the assistance of heat, the saccharine acid is totally destroyed.

* Keir's Chemical Dictionary, page 161.

The marine acid and vinegar dissolve the crystals very completely, but do not produce any change in their properties.

One hundred parts of spirit of wine take up nearly fifty-six of this acid at a boiling heat, but not above forty in a moderate heat. This solution becomes somewhat turbid, and deposits a mucous sediment, equal to nearly one fortieth of the acid. On cooling, scaly crystals are separated, of an irregular form and fragrant smell, which grow white in drying. Two drams of the crystals dissolved in the same quantity of ardent spirit, of the specific gravity of 0.8581, were boiled over a slow fire in a small retort. The first half dram which came over was nothing but the spirit deprived of its superfluous phlegm; after which striae began to appear in the retort, and a dram of an acid liquor came over, which upon evaporation yielded a crystallized saccharine acid. Upon the addition of lime-water, the saline combination of acid of sugar and lime fell to the bottom, and on the top there floated a thin stratum of ether, which differs much from the common ether, for it has but a weak smell, is not inflammable except when hot, and does not burn with a white, but with a blue flame, only white on the surface.

Vitriolic ether dissolves the crystallized acid of sugar, but with difficulty. Oils, both essential and expressed, dissolve it; but it separates upon due evaporation of the former, or in a more violent heat of the latter it separates by rising above the surface.

This acid effloresces in an heat exceeding 60°, the crystals losing about three tenths of their weight by falling into a white powder. This loss, which consists merely of water of crystallization, is quickly recovered in a moist air.

When the acid of sugar is exposed to heat in low distilling vessels, the water of crystallization first comes over in the quantity above specified. As the heat becomes greater, the acid melts, and grows brown when boiling hot: a little phlegm comes over: an acid powder effloresces upon the luting of the receiver, and a white saline crust sublimes, which consists of acid of sugar in a very pure state. The residuum is of a brown or grey colour, and empyreumatic smell, and flies off if exposed to the fire in an open vessel. In the receiver is found an acid liquor, which has the properties of acid of sugar, but does not easily crystallize. During this operation a great part of the acid of sugar is destroyed, and a large quantity of aerial fluid escapes, which on examination is found to consist of about one half fixed air absorbable by lime water, and the rest heavy inflammable air, which burns with a blue flame. If the sublimed acid of sugar be again and again exposed to heat, its decomposition is still farther effected, and more speedily in open than close vessels. It affords no vestiges of coal; a circumstance that distinguishes it from the acid of tartar.

The combination of acid of sugar with vegetable alkali does not easily afford crystals when saturated; but if either the acid or alkali be rather in excess, the solution affords crystals without difficulty. Two parts of perfectly mild alkali being combined with one of saccharine acid, and carefully evaporated, afford beautiful prismatic crystals, nearly of the same form as those of the acid itself, which are very soluble in water, but less so in ardent spirit. Lime, ponderous earth, or magnesia, separate the acid from these crystals. As the saccharine acid has a stronger attraction for lime than any other acid has, and forms an insoluble compound with that earth, it is used as a test to discover its presence in all solutions: and though the acid alone is capable of throwing down this insoluble compound, yet the combination of acid of sugar and vegetable alkali operates more speedily by means of the double affinity.

Two parts of newly crystallized mineral alkali, combined with one of saccharine acid, form a salt of very difficult solubility; part of which falls down at the time of combination, and the remaining solution affords crystals which dissolve perfectly in warm water, but not in ardent spirit. In its other properties this salt resembles that formed with the vegetable alkali; but the mineral alkali is expelled by the vegetable.

The combination of acid of sugar with volatile alkali affords quadrangular prismatic crystals by slow evaporation, which are soluble in water, but not in ardent spirit. By destructive distillation they afford, first, a concrete or mild volatile alkali, and then a portion of volatile alkali combined with acid of sugar. A coaly residuum is left, which indicates a decomposition of the salt; and the mild state of the volatile alkali which first comes over, shews that a portion of fixed air was extricated, no doubt, from the acid of sugar. Fixed alkalis and the soluble earths decompose this salt.

Eighty-two parts of saccharine acid dissolve one hundred of transparent calcareous spar, though slowly, because the first action of the acid on the lime forms a nearly insoluble compound, which covers and in some measure defends the internal parts of the spar. When lime is dissolved in nitrous acid, it is completely precipitated by acid of sugar, in the form of a white powder not soluble in water. Of 119 parts by weight of this powder, 72 fall to the bottom, and 47 appear upon evaporation. Hence it appears that 100 parts contain of acid 48, of pure lime 46, and of water 6; so that not only the presence of lime in water may be discovered, but also its quantity, from the weight of the precipitate.

The acid of sugar, saturated with ponderous earth, is very sparingly soluble in water, and does not crystallize unless the acid be in excess. Hot water takes away this superabundant acid from part of the crystals, and therefore throws down a precipitate; pure vegetable alkali causes a precipitate for the same reason, namely, because it seizes the superabundant acid. The crystals of this salt are scarcely soluble in ardent spirit.

Magnesia likewise forms a salt with the acid of sugar, which is not soluble either in water or ardent spirit, unless the acid be superabundant. One hundred parts of this salt contain 35 of pure magnesia, and 65 of acid and water. The fluor acid is the only one which decomposes this salt: lime and ponderous earth likewise seize its acid; but alkalis do not.

Of pure clay, or earth of alum, well washed, forty-two parts are dissolved by digestion with 53 of acid of sugar. This solution does not afford crystals by evaporation, but a yellowish pellucid mass of a sweet though astringent taste; which when dry deliquesces in a moist air, and gains $\frac{2}{3}$ of its weight. This reddens tincture of turnsole, but not syrup of violets. It is sparingly soluble in spirit of wine; swells in the fire, and loses its acid, a brown earth remaining behind. One hundred parts of this argillaceous salt contain about 44 of earth, and 56 of acid and water. It is decomposed by the vitriolic, nitrous, and marine acids, the alkaline salts, ponderous earth, lime, and magnesia.

No action takes place between the solution of saccharine acid and gold in the metallic state; but if the metal be precipitated by an alkali from its solution in aqua regia, and then well washed, the saccharine acid blackens, but scarcely dissolves it. Platina is not dissolved, unless precipitated by an alkali. When this metal is precipitated by the mineral alkali, and well washed, it forms a yellow solution with the acid of sugar, which affords yellow crystals. Silver is not attacked by the acid of sugar, and its precipitate by an alkali is very feebly acted on. If the saccharine acid

acid be added to a nitrous solution of silver, it seizes the metal, with which it falls down in the form of a white powder, scarcely soluble in water, and still less in ardent spirits, but soluble in the nitrous acid. This powder when well washed does not change even the tincture of turnsole. The rays of the sun convert it to a black colour. The solution of silver in the vitriolic acid is also decomposed by acid of sugar, but the marine solution does not appear to be decomposable.

Mercury is not acted upon by the saccharine acid, unless it be in the state of calx, and in this case it is dissolved, forming a powdery white salt, which is not soluble in water, unless the acid predominates, and which grows black by exposure to the sun's rays. The same combination may be had by adding saccharine acid to the nitrous solution of mercury. The precipitate afforded in this way by corrosive sublimate does not grow black in the sun. Lead in the metallic state is corroded, but scarcely dissolved in this acid, unless it be calcined, especially by precipitation with an alkali. The solution lets fall saline grains as it approaches towards saturation. The same combination may be had by adding the saccharine acid to the nitrous, marine, or acetous solutions of lead. The crystals are not soluble in ardent spirit, and scarcely in water, unless it be sharpened with an acid. The crystals contain about 55 parts of lead in the hundred. Lead is not precipitated from the vitriolic by the saccharine acid. Copper in its metallic state is attacked by the acid of sugar, but more readily if it has been precipitated by an alkali. The solutions form a powder of a faint blue colour sparingly soluble in water, unless the acid be in excess. The cupreous solutions in vitriolic, nitrous, or marine acids, are precipitated by saccharine acid; and the solution of the acetous salt of copper is so completely decomposed by this acid, that the concentrated vinegar remains with a very small portion of copper in solution. Iron, whether metallic or calcined, is soluble in the acid of sugar. The solution of metallic iron is attended with effervescence and the escape of inflammable air, and affords crystals with a superabundance of acid, and soluble in water. Tin is slowly dissolved, as is likewise its calx more readily. Both solutions possess an excess of acid, and the former exhibits crystals.

Regulus of bismuth is somewhat corroded by the acid of sugar, but the calx only is dissolved, forming a powdery white salt, very sparingly soluble in water, and containing half its weight of metal. If saccharine acid be added to the nitrous solution of bismuth, there will be formed, in the space of half an hour, transparent polygonal grains, which have the same properties as the powdery white salt, and do not occasion opacity in water, as the crystals of the nitrous salt of bismuth do. Nickel is converted, by digestion with saccharine acid, into a greenish white powder, as is also the green calx of this semi-metal, without the assistance of heat. This combination contains twice as much acid as metal. The saccharine acid precipitates a powder of the same kind from the vitriolic, nitrous, or marine solutions of nickel. This salt is soluble in a large quantity of water, and assumes a yellow colour. Reguline arsenic is scarcely dissolved by digestion in acid of sugar; but the white calx is easily taken up without heat. This solution affords prismatic crystals by evaporation, which melt in a gentle heat, emit the superabundant acid, and shoot into elegant ramifications; they are very soluble in water, and in ardent spirits; redden turnsole; are sublimed by a moderate heat; but decomposed by a stronger, the saccharine acid first flying off, and afterwards the arsenical calx. Cobalt is attacked, either with or without heat, by this acid, which converts it into a faint rose-coloured powder. The solution is yellow, and exhibits crystals more easily soluble, because abounding in acid; but the rose-coloured powder is scarcely soluble. The acid of sugar separates cobalt from all the known acids, and forms the rose-coloured powder. Metallic zinc effervesces

effervesces strongly with saccharine acid, and soon becomes covered with a white powder. This contains 75 parts of metal in the hundred, and is not soluble in water unless by excess of acid. The calx of zinc affords a similar powder, and the like combination is obtained by adding acid of sugar to the vitriolic, nitrous, or marine solutions of zinc. The regulus of antimony grows black by digestion with saccharine acid: but the calx and the glass are slowly dissolved. The solution, which always contains an excess of acid, exhibits crystalline grains of difficult solubility in water. Manganese, in the form of the black calx, effervesces with this acid even in the cold; but the saturated solution deposits a white powder nearly insoluble in water, unless the acid predominate. This salt grows black in the fire, but recovers its whiteness upon the addition of more acid. The saccharine acid precipitates a white powder of the same nature, mixed with some crystalline grains, from the vitriolic, nitrous, or marine solutions of manganese*.

The theory of the saccharine acid is evidently of the same nature as that of every other combustible substance which acquires acid properties. In the original theory of chemistry, which was chiefly attended to by the illustrious Bergman (to whom we are indebted for most of the researches included in the present article), the nitrous acid is supposed to do little more than deprive the sugar of a certain quantity of phlogiston, which concealed the acid already existing in the sugar, by neutralizing it, or masking its properties. Others, however, though with less probability, have inferred, that the acid of sugar consists merely of the nitrous acid, altered by the phlogiston or some other principle of the sugar; an opinion which seems to be sufficiently confuted by the discovery of the saccharine acid in the salt of sorrel, wherein the previous existence of nitrous acid cannot be proved, and which we may hope to see placed upon still less equivocal ground, if this acid should ever be produced by art in the way of actual combustion, or by the combination of vital air with the saccharine basis, whether by a speedy or slow process.

We have elsewhere had frequent occasion, however, to observe, that the facts will not admit of the mere supposition that dephlogistication is the cause of acidity, because it is sufficiently established, that an absorption of vital air takes place in this as well as other processes analogous to combustion. Admitting, therefore, that sugar (or some principle common to sugar, gums, mucilages, hair, and the other bodies which afford this acid) is acidified by the absorption of vital air, and waving the question how far the disengagement of an inflammable principle may take place, the chief object of enquiry will relate not to the nitrous acid that causes the acidification, but to the principle or basis on which the peculiar properties of this acid depend. In this research, as we have no direct or synthetical experiments, we must attend to the analyses that take place by fire and by fermentation. In the destructive distillation of saccharine acid, we have scarcely any products but fixed air and heavy inflammable air, which last is with considerable probability taken to be a combination of light inflammable air and fixed air. Again it is found, that when the boiling with nitrous acid is continued too long, or the acid is stronger than it ought to be, a quantity of fixed air is extricated, and the saccharine acid is in a great measure converted into the acetous. It is likewise found, that when sugar is treated with a weak nitrous acid, the produce is the acid of tartar, instead of that peculiarly distinguished by the name of saccharine. When a solution of sugar in water is exposed to fermentation or spontaneous decomposition, a considerable quantity of fixed air escapes, mucilage subsides, and the fluid contains ardent spirit, a substance eminently inflammable, but which affords saccha-

* Bergman de Acido Sacchari,

rine acid, when properly treated, with the nitrous. During the subsequent stages of the fermentation, vital air is absorbed, and the ardent spirit is no longer found, but is converted into vinegar. Whether the intermediate acids may be produced, or do exist, for any determinate space of time in this process, is not known.

From these circumstances, it appears very probable, that an inflammable principle, existing in sugar and many other bodies, is in the several processes brought nearer to the state of perfect acidity, accordingly as it absorbs a greater quantity of vital air; that fixed air, vinegar, acid of sugar, and acid of tartar, are substances in which this inflammable principle is more and more abundant, and are therefore convertible into each other, by dephlogistication, or the addition of vital air, though chemistry has not yet obtained the means of reversing the processes by the subtraction of the same principle. Sugar is probably converted into ardent spirit by such a natural reversing, in which fixed air or the most perfect vegetable acid flies off, and leaves a more inflammable substance, which afterwards attracts the vital parts of the atmosphere, and becomes vinegar.

From this view of the subject, it will follow that the combustible substance is the basis of fixed air: this is supposed, by the antiphlogistic philosophers, to be charcoal, or a peculiar principle most eminently abundant in vegetable coal; but the English philosophers, particularly Dr. Priestley, infer, that this principle is nothing else but inflammable air. The antiphlogistic philosophers derive the inflammable air that appears in these and other similar operations from the water, which they take to be decomposed.

ACID OF SUGAR, EMPYREUMATIC. When sugar is distilled without addition in a retort, a fluid acid liquor and oil pass into the receiver. Mr. Schrickel * has purified and concentrated this acid liquor, and investigated its properties. From sixteen ounces of fine sugar he obtained, by distillation, water, acid, and oil, amounting to eight ounces, four scruples, and a carbonaceous residue which weighed seven ounces and two scruples: so that six drachms were lost in the operation. The first liquor which distilled was about six drachms in weight, scarcely acid, and was little else than water. The acid then passed in white vapours, and condensed on the sides of the receiver in striae, which seemed as if they were dense and unctuous. This acid liquor had a pungent but pleasant smell; in taste it was sharp, bitter, sour, and empyreumatic; and in colour of a yellowish red. It affected the colour of syrup of violets but little, neither did it effervesce much with mild alkali. The oil which passed in distillation was at first yellow, then became black and thick, and the whole quantity was about one ounce. This oil, by rectification, was rendered of a fine yellow colour, was specifically heavier than the acid liquor, was bitter, sharp, and dry to the taste, and was soluble in spirit of wine.

The empyreumatic acid liquor was rendered, by repeated abstractions from pure clay, perfectly clear, mild in smell, acid to the taste, and capable of effervescing with mild alkalis. By means of frost, Mr. Schrickel concentrated this acid, and combined it with different substances.

With vegetable fixed alkali he obtained a neutral salt, consisting of needle-shaped crystals, which tasted like salt of Sylvius, were soluble with difficulty in cold water, but not at all in spirit of wine, remained dry in air, decrepitated and became white, but did not melt on hot coals.

The mineral alkali, saturated with this acid, gave, after a very short evaporation,

* *De salibus saccharinis vegetalibus & sacchari albi vulgaris, analysi, acidoque hujus spiritus.* Giesse, 1776. Quoted by Kier in his Dictionary, from which the present article is taken.

shining yellow, six-sided, sharp-pointed crystals, which in taste resembled salt of Seignette; were easily soluble in water, but not in spirit of wine; remained dry in a dry air, but liquefied with a gentle heat, and in the fire were changed into a brown carbonaceous residuum.

With volatile alkali, this acid gave a sharp saline liquor, which formed a saline mass without any determinate form, or crystallization.

With calcareous earth, a similar saline mass was formed, which could be decomposed either by an alkali, or by vitriolic acid.

Magnesia gave a gummy mass, which, when dried, was like a hardened white of an egg.

Argillaceous or aluminous earth formed a gummy astringent saline mass.

The concentrated acid dissolved easily the calx of gold, and even gold-leaf. It exerted no action on silver, mercury, or their calces. Partly it calcined, and partly it tarnished lead. With minium it gave a yellow solution, which was not altered by nitrous acid, but gave a white precipitate on the addition of vitriolic and marine acids, or of alkalis, and a grey precipitate by means of infusion of galls. This solution of minium shot into white, oblong crystals, of an astringent taste. With filings of iron this acid gave a sweetish, austere, and blood-red solution, in which green crystals shot. From a solution of these crystals, alkalis produced a green precipitate, the Prussian lixivium gave a black or dark blue precipitate, and marine acid a white precipitate. Vitriolic and nitrous acids occasioned no precipitation. Copper is dissolved by this distilled acid; and when the acid is very strong, the metal is corroded into a brownish green calx. The solution of copper does not crystallize, is green, forms with alkalis green precipitate, with infusion of galls a yellowish green precipitate, but affords none by means of the mineral acids. Regulus of antimony gives a greenish solution with the distilled acid of sugar, and is thence precipitated of a yellow colour by fixed alkali; by volatile alkali as a powder that is again soluble by the precipitant, by vitriolic and marine acids, and also by an infusion of galls, as a white powder; but is not at all separated from its solvent by nitrous acid. This acid partly dissolves zinc, and forms a greenish solution, and partly calcines it to a greyish yellow powder. This solution gives a white precipitate on addition of infusion of galls, alkalis, fixed, volatile, or phlogisticated, or of vitriolic acid. Tin is partly dissolved, but principally corroded by this acid into a greyish powder. The solution is precipitated by alkalis, and by an infusion of galls, but not by any of the mineral acids.

ACID OF SUGAR OF MILK. The sugar which is obtained by evaporation of whey differs little from the sugar of vegetables. When treated with nitrous acid, in the manner of producing the saccharine acid, this last acid is not only afforded, but likewise another, which, because first discovered in this peculiar sugar, was denominated the acid of sugar of milk*.

Twelve ounces of diluted nitrous acid being poured upon four ounces of finely powdered sugar of milk, in a glass retort on a sand bath, with a receiver annexed, the mixture became gradually hot, and at length effervesced violently, and continued to do so for a considerable time after the retort was taken from the fire. It is necessary therefore, in this experiment, to use a large retort, and not to lute the receiver too tight. After the effervescence had in some measure subsided, the retort was again placed on the sand bath, and the nitrous acid distilled off till the mass had acquired a yellowish colour. This yellow fluid exhibited no crystals. Eight ounces

* By Scheele. See *Essays*, Eng. translation, p. 278.

more of the same nitrous acid were therefore added, and the distillation again repeated, till the yellow colour of the fluid disappeared. The fluid became inspissated by cooling; for which reason it was re-dissolved in eight ounces of water, and filtered. Seven drams and a half of a white powder remained on the filter, and the clear solution afforded crystals of saccharine acid. The mother water was again treated several times with nitrous acid, by which means the whole was at length changed into saccharine acid.

The white powder that remained on the filter was found to be combustible like oil, in a red hot crucible, without leaving any mark of ashes behind. It was soluble in sixty times its weight of boiling water; and one fourth part separated by cooling in the form of very small crystals. The remaining mass being then collected by evaporating the greatest part of the water, left behind a small portion of the acid of sugar, from which it had not been so exactly deprived by edulcoration on the filter. From these circumstances it appeared, that the white matter was a salt, and, upon examination, it proved to be an acid possessing the following properties:

This acid, or the acid of sugar of milk, forms with the soluble earths salts insoluble in water. It disengages fixed air from the mild alkalis. With the vegetable alkali it forms a salt soluble in eight times its weight of boiling water, but separable for the most part by cooling. With the mineral alkali it affords a salt that requires only five parts of boiling water for its solution. Both these salts are perfectly neutral. When saturated with volatile alkali, it forms a salt which, after being gently dried, has a sourish taste. It does not perceptibly act on the metals, perhaps because so little concentrated; but it forms with their calces salts of very difficult solubility, which therefore fall down.

Gumtragacanth and some other vegetable mucilages also afford this acid.

ACID OF TARTAR. Tartar was a long time considered as one of the products of the vinous fermentation, because it is obtained, for the purposes of commerce, from wine, during the insensible fermentation of which liquid it is gradually deposited on the sides of the casks. But it exists ready formed in must, in verjuice, in tamarinds, strawberries, peaches, gooseberries, apricots, raspberries, mulberries, apples, pears, barberries, and pomegranates, from all which it may be extracted by expressing their juice, and exposing it to congelation, which alters and destroys the mucilage, and converts great part of the aqueous fluid into ice, without producing that considerable change in the remaining fluid which evaporation by heat would not fail to do. As soon as the fluids have lost three fourths or more of their weight, by taking away the ice as it is formed, a saline deposition, loaded with the colouring and extractive matter of the fruit, falls to the bottom of the vessels; and this, after purification by repeated washings in small quantities of cold water and of ardent spirit, becomes at length purified, and is found, on examination, to be cream of tartar: for it affords the same combinations with alkaline salts, has the same habitudes in the fire, and, in a word, does not differ from that substance. In this course of experiments fixed and constant results are not to be expected, unless a considerable quantity of each fruit be used: for in most of them the saline part is so small in quantity, and so enveloped in mucilage, that it would scarcely be rendered perceptible if only an ordinary quantity were used, and more especially if the fruit were perfectly ripe*.

Crude tartar is seldom used in medicine, or philosophical chemistry; the refined tartar is known by the name of cream, or crystals of tartar. The purification of this

* De Laffone and Cornette, in the Memoirs of the Royal Academy of Sciences at Paris, for the year 1786, p. 606.

salt is effected by dissolving it in boiling water, filtering, and suffering it to crystallize by cooling; the crystals are again boiled, together with an argillaceous earth, to deprive them of their impurities, which are carefully scummed off; or else with whites of eggs, which answers the same purpose. When no more scum arises, a saline pellicle is formed at the top of the liquor, at the same time that the crystallization goes forward at the bottom. This salt, after the earth is washed off with cold water, is sold under the name of cream, and crystals of tartar. The cream of tartar consists of the minute crystals which are formed at the top of the liquor, and the crystals of tartar are formed at the bottom.

The taste of this purified salt is less vinous than that of the crude tartar. When exposed to heat it boils up, emits an empyreumatic smell, and becomes black and coaly: a stronger heat, in an open fire, entirely dissipates its acid part, and leaves the vegetable alkali in a mild state, or combined with fixed air. Its volatile products, by a gradual fire, are water, an acid, and an empyreumatic oil, which is followed by some volatile alkali, and a large quantity of fixed air. Crystals of tartar are soluble in twenty-eight parts of boiling water; three fourths of the salt are deposited in cooling. If the solution of this salt be left exposed to the air, it is very slowly decomposed; mucilage is deposited, the acid disappears, and after eighteen months the liquid is found to contain the vegetable alkali, amounting to nearly one fourth of the weight of the tartar. This quantity of alkali being nearly the same as is afforded by the incineration of tartar, is a proof that the vegetable alkali is not a product of fire, as was formerly supposed.

Cream of tartar consists of a peculiar acid, or the acid of tartar united with a less quantity of alkali than is sufficient to saturate it, or deprive it of acid properties. Saturation being distinguished by the mutual counterpoise or most perfect re-action of the properties of two substances which enter into combination, is observed in general to take place when the proportions of the principles are such as tend most strongly to form a separate combination in the solid state. The cream of tartar and a few other neutral salts afford curious exceptions to this general rule. Of the acid and the alkali, both of which are soluble in small quantities of water, and therefore not easily separable from that fluid, a compound is formed, which is so sparingly soluble as to require more than eighty times its weight of cold water to suspend it. This compound, or cream of tartar, is rendered more soluble by increasing either the acid or the alkali beyond the due proportion; and the most remarkable circumstance is, that this happens, as we have already remarked, not at the point of saturation, but at that in which the acid so considerably abounds.

If to twenty ounces of purified tartar, dissolved in four pounds of boiling water, the pure crystallized mineral alkali be added, until the saturation be complete, as may be judged by any additional quantity producing no effervescence, the alkali last added will combine with the superfluous acid of the tartar, and form the neutral combination called the salt of Seignette, or Rochelle salt; at the same time that the residue of the tartar will become converted into soluble tartar. By evaporating the liquor nearly to the consistence of syrup, the Rochelle salt is obtained in beautiful regular prisms, of six or eight sides, which effloresce in the air, and are decomposed by heat in the same manner as soluble tartar.

By the same treatment with volatile alkali, an ammoniacal tartareous salt is formed, which affords crystals that effloresce in the air.

If the mineral acids be added to tartar, they combine with its alkali, and form the same salts as they would have produced by direct union with the vegetable alkali.

Tartar has long been an object of attention with chemists, and it is used as an acid in many of the arts. This salt appears to be capable of uniting without decomposition, and forming triple salts with most of the metals.

The pure acid of tartar may be obtained by saturating three parts of cream of tartar with chalk or lime; the former of which combines with the superfluous acid, and the latter seizes the whole. The calcareous tartar, which on account of its insolubility remains at the bottom, is then to be well washed, and digested with about one part of vitriolic acid, together with a sufficient quantity of water. In this manner the acid of tartar is disengaged. The selenite, formed by the combination of the vitriolic acid and the lime, will be separated and fall down by evaporating the water; and the acid which remains may be crystallized by further evaporation and cooling.

Or, more simply, one pound of cream of tartar may be boiled in five or six pounds of water, and a quarter of a pound of clear and colourless dense vitriolic acid may be added by little and little. When a complete solution is obtained, the fluid will then contain disengaged acid of tartar, together with vitriolated tartar, or the neutral salt, formed by the union of the vitriolic acid with the vegetable alkali. The vitriolated tartar, being a salt of sparing solubility, will be precipitated by continuing the boiling. When the liquor is evaporated to one half, it is to be filtered; and if, upon further evaporation, any thing more is precipitated, it must be filtered again. The clear liquor being then reduced to the consistence of a syrup, and set aside in a temperate or rather warm place, will afford fine crystals of tartareous acid, equal in weight to half the cream of tartar employed. If too small a quantity of vitriolic acid has been used, part of the cream of tartar will not be decomposed, but will separate from the liquor along with the vitriolated tartar. It is better therefore to use too little, rather than too much.

The crystallized tartareous acid melts, fumes, becomes black, and burns, by the contact of ignited bodies. By distillation it affords an acid phlegm, a small quantity of oil, and much fixed air, together with inflammable air, leaving behind a coaly residue, which contains neither acid nor alkali.

The crystals of tartareous acid do not change by exposure to air; they are much more soluble in water than cream of tartar itself. This acid dissolves clay, and forms a salt which, by evaporation, assumes a clear gummy consistence, and does not deliquesce in the air. The same appearance is exhibited with magnesia: with lime it forms a salt which is scarcely at all soluble; a due proportion of vegetable alkali converts tartareous acid into cream of tartar, which falls down if the water of solution be not sufficiently abundant, but is dissolved again if more alkali be added, so as to convert it into soluble tartar. These synthetical operations shew that the tartareous acid is not altered by the process of extracting it from cream of tartar.

With mineral alkali it forms the Rochelle salt, and with volatile alkali it forms a crystallizable salt. In this last combination, which has a neutral cooling taste resembling that of nitre, there is a term at which crystals of sparing solubility, like those of cream of tartar, are formed; for which reason it is necessary, in preparing the neutral salt, to add a sufficient quantity of alkali at once to saturate the acid, because in this case of insoluble crystals likewise, the proportion of acid is considerably more than is required for the due saturation.

Gold, in the metallic state, is not acted upon by the tartareous acid, though it unites with the precipitate afforded by adding an alkali to a solution of that metal. Platina likewise is said to be soluble in cream of tartar after it has been precipitated by alkali, though not in its metallic state. The precipitate of silver, from nitrous acid

by an alkali, unites with the tartareous acid into a saline mass, which turns black by exposure to light, and from which the silver may be separated, in its metallic state, by quicksilver, as well as by other metals. Mercury is changed into a kind of ethiops or black powder by the tartareous acid; which also acts upon mercurial calces, and converts them into yellow powders. A solution of tartareous acid being added to the nitrous solution of mercury, a precipitate of tartarized mercury falls down: but this acid does not cause any precipitate in a solution of corrosive sublimate, unless an alkali be at the same time added to engage the marine acid. Copper, in its metallic state, is scarcely attacked by the acid of tartar; but the calces of this metal are considerably acted upon. It precipitates solutions of copper in the vitriolic and marine acids, the tartareous acid uniting with the calx of the metal in the form of blue crystals. This blue salt forms the better kind of the pigment called Brunswick green. Lead is precipitated by the acid of tartar from its solution in the nitrous, marine, or acetous acids. The precipitate, which is a tartarized lead, is soluble in nitrous acid, and decomposable by the vitriolic. It is difficultly soluble in water; whereas the salt formed by uniting calx of lead with cream of tartar is said to be easily soluble. The acid of tartar deprives minium of its colour. Iron is attacked by this acid with a slow effervescence, during which the metal is precipitated in the form of a granulated grey powder; and when a solution of this metal in water is mixed with a solution of martial vitriol, and the mixture evaporated to half its quantity, scaly crystals of a ferruginous taste will be formed. Tartareous acid has no action upon tin, and its action upon the calces of tin has not yet been ascertained. Tartar itself is known to possess some dissolving power on tin, and is capable of uniting with its calx into a crystallizable and soluble salt. When this acid is added to the nitrous solution of bismuth, a tartarized bismuth soon appears in the form of crystalline grains. The action of the acid of tartar in its pure state upon nickel, arsenic, and regulus of cobalt, has not yet been ascertained. It dissolves zinc with great facility, and affords a difficultly soluble salt; whereas the tartar itself forms a soluble and even deliquescent salt. Regulus of antimony suffers no change from the action of this acid, but it combines with the calces*.

The acid of tartar is convertible into the saccharine acid, by distillation with strong nitrous acid. Digestion with water and ardent spirit converts it into vinegar.

ACID OF TIN. This metal is converted into an acid by treatment with the acid of nitre. *See* TIN.

ACID OF TUNGSTEN, or WOLFRAM. The mineral called tungsten, or heavy stone, was first analyzed by Scheele and Bergman, and afterwards more completely examined by Messrs. De Luyarts. As the tungsten consists of a metallic acid united with lime, neither of which substances are soluble in one and the same menstruum in any considerable quantity, the analysis of this stone in the humid way has been a matter of considerable difficulty: for when an acid is added to dissolve the lime, it unites with such particles as lie near the surface of the tungsten, and cannot afterwards proceed in its action, because its further progress is prevented by the acid of tungsten which envelopes the remaining lime that occupies the interior part of the stone. And again, when an alkali is added to dissolve the acid of tungsten, its action is likewise merely superficial, because it meets with a similar impediment from particles of lime which defend the acid in the interior parts of the stone from its progressive action.

The ingenious chemists, who have busied themselves in this examination, could

* Kier's Dictionary, page 173.

recur therefore to no other humid process than that of boiling, first an acid, and afterwards an alkali, upon the pulverized stone, and repeating these processes alternately until the whole was dissolved. The tungsten is not altered by the action of boiling water. Two parts of concentrated vitriolic acid being distilled from one part of finely powdered tungsten, the acid came over unchanged, and the residuum, which was of a bluish colour, afforded some selenite by boiling in distilled water. Three parts of nitrous acid being poured on one part of finely powdered tungsten produced no effervescence; but, upon the mixture being put into strong digestion, the powder soon assumed a lemon colour. The acid was then decanted off, and the yellow powder, after edulcoration, was heated with two parts of caustic volatile alkali, which soon destroyed the yellow colour of the powder, and rendered it white. This menstruum was likewise decanted off, and the powder again edulcorated. In this manner Scheele proceeded, by digesting the same portion of tungsten, first in the nitrous acid, and then in the volatile alkali, till at length the greatest part was dissolved. The remainder was little more than a thirtieth of the whole, and seemed to be siliceous. Marine acid produces the same effect upon tungsten, but the stone becomes more strongly yellow.

All the acid solutions being mixed together, afforded a small portion of iron when the Prussian alkali was added. Volatile alkali afforded no precipitate; but, upon the addition of mild vegetable alkali, a mild calcareous earth fell down, which weighed a little more than half the weight of the tungsten. The solutions made by the volatile alkali were also mixed together, and nitrous acid was gradually added. A precipitate fell down of a white colour, which was washed with cold water and dried. This precipitate proved to be of an acid nature, having a sour taste, affording a red colour to tincture of litmus, and being soluble in near twenty parts of boiling water.

The products afforded by tungsten in this way, consisting of calcareous earth and the white acid powder, it was natural to infer that these were the component parts of the stone; and it remained only to confirm this operation by synthetically producing tungsten from the union of its principles. One part of the acid solution was therefore added to six parts of clear lime-water, which immediately became a little turbid; but as, after an interval of some hours, nothing had sunk to the bottom, the mixture was made to boil, and immediately afforded an heavy white powder, which had the same habitudes with the vitriolic and nitrous acids, and with the blow-pipe, as the tungsten itself, and consequently was that substance.

Fire does not produce any perceptible change in tungsten, nor does the glass of borax produce any sensible effect upon it, according to the experiments of Scheele, which perhaps were made in a crucible. Bergman found that it decrepitated before the blow-pipe, but did not melt, and was soluble in borax without effervescence, and almost without colour, except when the globule was overloaded with tungsten, in which case it becomes brown or white in cooling, and loses its transparency. Microcosmic salt forms with tungsten a glass of a sea-green or pure blue colour. The green colour, as observed by Scheele, disappears by the addition of nitre, but returns when the blue part of the flame is driven on the globule; a circumstance which shews that the colour disappears by a more perfect calcination of the metallic acid of the tungsten, and is restored by a degree of reduction in the interior part of the flame, as is likewise observed with manganese; *see* MANGANESE. For the dry analysis of tungsten, one part of the stone, rubbed to a fine powder in a glass mortar, was mixed with four parts of alkali of tartar, and placed in the fire in an iron crucible. The mixture, when melted, was poured out upon an iron plate, and dissolved

in twelve parts of boiling water. After standing some hours, this lixivium was decanted off from a portion of white powder which had subsided to the bottom. Acid of nitre dissolved a great part of this powder previouslyedulcorated. The undissolved part, or tungsten which had escaped the action of the alkali during the fusion, being again dried, mixed with four parts of alkali of tartar, and brought into fusion as before, left a powder undissolved upon the addition of water, the whole of which was soluble in nitrous acid, excepting a very small portion of a grey powder. In this way the component parts of the tungsten afforded an alkaline and an acid solution. To the alkaline solution nitrous acid was added to saturation, upon which a white powder fell down, which having the property of regenerating tungsten by the addition of lime, was concluded to be the acid of tungsten : and the nitrous acid solution being likewise neutralized by adding the mild vegetable alkali, afforded a white precipitate, which was dried, and proved to be mild calcareous earth. Hence it follows that the dry analysis afforded the same products as that in the humid way.

To the experiments of Scheele, which had likewise been made by Bergman, others were added in confirmation by this last chemist, who suspected the acid to be of a metallic nature, for reasons which, though they do honour to his sagacity, need not be here recited, because his suspicions have been since established by the more perfect analysis of his pupils, the Messrs. Luyarts. These gentlemen undertook to examine the mineral called wolfram, concerning which we before possessed little more than conjectures. The wolfram they examined is of a brownish black colour, found in scattered masses, crystallized into six-sided flat prisms, terminating in four-sided oblique pyramids. In its fracture it shines with a lustre almost metallic. Its texture is irregularly laminated, and very seldom striated. It is always opaque, yields a dark reddish grey powder when scraped, is soft, and has a specific gravity of 6.835. This wolfram was obtained from the tin mines of Zinnwald, on the frontiers of Saxony and Bohemia.

The blow-pipe has no other effect upon it than merely to round its angles. Microscopic salt unites with it with effervescence, and forms a glass of a pale red in the exterior flame, and much darker in the interior. With borax it likewise effervesces, and forms in the interior flame a glass of a greenish yellow, which in the exterior flame turns reddish. The wolfram, kept for an hour in a crucible strongly heated, became semi-vitrified, spongy, of a brownish colour, and yielded to the magnet. Equal parts of nitre and wolfram detonated weakly in a red hot crucible, and emitted nitrous vapours. The combination being afterwards mixed with water, dissolved in part, and the clean solution afforded a white precipitate upon the addition of a few drops of acid. This precipitate was the same substance as the tungsten acid of Scheele obtained in the dry way.

Two parts of pulverized wolfram melted without difficulty with four of vegetable alkali; about one third of the wolfram was not dissolved by the alkali, and this third part proved to be iron and manganese. The rest was dissolved in water, and, upon the gradual addition of nitrous acid, afforded a white precipitate, of the same nature as the acid substance obtained, in the dry way, from tungsten by Scheele and Bergman.

This white saline substance, which those chemists inferred to be a simple acid, was proved by the Messrs. Luyarts to be a compound, consisting of the calx or true acid of wolfram combined with a portion both of the alkali and of the precipitating acid. Its general properties they found to be as follow :

With the blow-pipe it melts alone ; and, when put to calcine in a little pot or test,
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it emits a smell of nitrous acid, and turns yellow; but, on cooling, it remains white, insipid, and insoluble. This residuum also melts in the blow-pipe. When either vitriolic, nitrous, or marine acid, is poured on this salt, they produce a yellow colour, and in the filtrated solution is found a neutral salt with base of fixed alkali corresponding with the acid employed. If this operation be performed with vitriolic acid in a retort, a portion of nitrous acid passes into the receiver, while the vitriolic acid forms vitriolated tartar. Whence it is clearly proved that the compound itself contains nitrous acid and vegetable alkali.

When regenerated tungsten was formed by adding lime-water to this white matter, the acid and alkali were found in the supernatant fluid.

Messrs. Luyarts analyzed wolfram likewise, in the humid way, by repeated alternate ebullitions of the powder with marine acid, edulcoration with water, and affusions of caustic volatile alkali. In this way the whole of the wolfram was at last dissolved, except about one fiftieth part, which was partly quartz, and partly seemed to be calx of tin. The acid solutions being examined, were found to contain iron and manganese, equal to somewhat more than one third of the whole; and the alkaline solutions, by evaporation, afforded the yellow calx of tungsten. They found likewise, by examining the precipitate of Scheele, from the volatile alkaline solution, by the addition of nitrous acid, that it contained volatile alkali and nitrous acid, as well as the yellow calx, instead of being a pure acid, as that chemist had concluded: for when tungsten is produced by the addition of lime-water to this precipitate, a smell of volatile alkali is emitted, and the supernatant fluid contains calcareous nitre.

The substance which therefore unites with lime in forming tungsten, and with manganese and iron in wolfram, is the yellow calx or acid which the Messrs. De Luyarts obtained from the alkaline solution, in the dry way, by precipitation with nitrous acid; repeated ebullition of nitrous acid on the precipitate to deprive it of all alkali; and lastly, calcination to expel the adhering nitrous acid: and, in the humid way, they obtained it by adding nitrous acid to the volatile alkaline solution, and afterwards depriving the precipitate of its adhering acid and volatile alkali, by calcining it likewise under a muffle. This is the true acid of wolfram, if indeed it may be termed an acid.

It possesses the following properties: 1. It is entirely insipid, and has a specific gravity of 6.12. 2. Before the blow-pipe it continues yellow in the exterior flame, although it be placed on charcoal; but in the interior flame it grows black and swells, but does not melt. It may be here observed, that the heating by the exterior flame may be considered as equivalent to an operation with access of air; and the heating by the interior flame answers to the heating in a closed vessel, because the surrounding flame prevents the access of air. Upon charcoal, therefore, the former calcines, while the latter reduces metallic bodies. 3. With microcosmic salt it unites with effervescence, and forms in the interior flame a transparent glass of a blue colour, more or less intense according to the proportion, but without any mixture of red. In the exterior flame the colour vanishes entirely, but returns again in the interior. These effects doubtless arise from the greater degree of calcination which the yellow matter suffers in the exterior flame, and of reduction in the interior flame. They cannot, however, be very often repeated, because, as Messrs. De Luyarts observe, the alkali of the ashes of the charcoal combines with the glass, and totally destroys the colour, as is proved by the addition of a small particle of alkali to the coloured glass in fusion. 4. With borax it forms a brownish yellow transparent glass, which keeps its colour in both flames. 5. This acid or yellow matter does not dissolve
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in water, but by trituration it forms an emulsion which passes through filters without becoming clear, and does not become entirely so in the course of three months. 6. The vitriolic, nitrous, and marine acids, have no action upon it, and do not form any emulsion with it by trituration. The acetous acid gives it a blue colour without dissolving it. 7. Caustic vegetable alkali completely dissolves it, both in the humid and dry way; but the produce always has an excess of alkali. When a few drops of nitrous acid are added to the alkaline solution, a white precipitate is instantly formed, which is re-dissolved by agitation as long as the alkali continues in excess, the liquor becoming more and more bitter; and when more acid is poured on than is necessary to saturate the excess, the precipitate which is formed is not re-dissolved. This white salt contains the yellow matter in combination with nitrous acid and vegetable alkali, and is in fact the substance which Scheele obtained from tungsten by fusion with vegetable alkali, and precipitation by nitrous acid, and distinguished by the name of acid of tungsten. 8. Volatile alkali likewise dissolves the yellow matter completely, but always with an excess of alkali. This solution affords crystals by evaporation, loses its alkali partly by boiling, and completely by calcination; affords a white precipitate by the addition of nitrous acid, which is perfectly similar to the tungsten acid of Scheele, when obtained by the medium of volatile alkali, and is completely decomposed by heat. 9. And lastly, this yellow matter may be revived into a metal by a strong heat with charcoal, in a covered crucible, and gains weight by calcination like other metallic bodies. See WOLFRAM.

The yellow colour, produced by the action of nitrous or marine acid, affords an easy test of the presence of the wolfram calx or acid in minerals.

ACIDS, VEGETABLE. See VEGETABLE KINGDOM.

ACID, VITRIOLIC, or OIL OF VITRIOL OF COMMERCE. When sulphur is heated in an open vessel, it melts, and soon afterwards emits a bluish flame, visible in the dark, but which, in open day-light, has the appearance of a white fume. This flame has a suffocating smell, and has so little heat that it will not set fire to flax, and may even be suffered to play against the palm of the hand without any considerable inconvenience. In this way the sulphur may be entirely consumed. If the heat be still augmented, the sulphur boils, and suddenly bursts into a much more luminous flame, the same suffocating vapour still continuing to be emitted.

The suffocating vapour of sulphur is imbibed by water, with which it forms the fluid called volatile vitriolic acid. If this fluid be exposed for a time to the air, it loses the sulphureous smell it had at first, and the acid becomes more fixed. It is then the fluid which was formerly called the spirit of vitriol. Much of the water may be driven off by heat, and the dense acid which remains is the vitriolic acid, commonly called oil of vitriol; a name which was probably given to it from the little noise it makes when poured out, and the unctuous feel it has when rubbed between the fingers, produced by its corroding and destroying the skin, with which it forms a soapy compound.

The stone or mineral called martial-pyrites, which consists for the most part of sulphur and iron, is found to be converted into the salt called vitriol of iron, by exposure to air and moisture. In this natural process the pyrites breaks and falls in pieces; and if the change takes place rapidly, a considerable increase of temperature follows, which is sometimes sufficient to set the mass on fire. By conducting this operation in an accurate way, it is found that vital air is absorbed. The vitriol is obtained by solution in water, and subsequent evaporation; by which the crystals of the salt are separated from the earthy impurities which were not suspended in the water.

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The vitriolic acid was formerly obtained in this country by distillation from vitriol of iron, as it still is in many parts abroad. The common green vitriol is made use of for this purpose, as it is to be met with at a low price, and the acid is most easily to be extracted from it. With respect to the operation itself, the following particulars should be attended to: First, the vitriol must be calcined in an iron or earthen vessel, till it appears of a yellowish red colour; by this operation it will lose half its weight. This is done in order to deprive it of the greatest part of the water which it has attracted into its crystals during the crystallization, and which would otherwise in the ensuing distillation greatly weaken the acid. As soon as the calcination is finished, the vitriol is to be put immediately, while it is warm, into a coated earthen retort, which is to be filled two thirds with it, so that the ingredients may have sufficient room upon being distended by the heat, and thus the bursting of the retort be prevented. It will be most advisable to have the retort immediately enclosed in brick-work in a reverberatory furnace, and to stop up the neck of it till the distillation begins, in order to prevent the materials from attracting fresh humidity from the air. At the beginning of the distillation the retort must be opened, and a moderate fire is to be applied to it, in order to expel from the vitriol all that part of the phlegm which does not taste strongly of the acid, and which may be received in an open vessel placed under the retort. But as soon as there appear any acid drops, a receiver is to be added, into which has been previously poured a quantity of the acidulous fluid which has come over, in the proportion of half a pound of it to twelve pounds of the calcined vitriol, when the receiver is to be secured with a proper luting. The fire is now to be raised by little and little to the most intense degree of heat, and the receiver carefully covered with wet cloths, and (in winter time) with snow or ice, as the acid rises in the form of a thick white vapour, which towards the end of the operation becomes hot, and heats the receiver to a great degree. The fire must be continued at this high pitch for several days, till no vapour issues from the retort, nor any drops are seen trickling down its sides. In the case of a great quantity of vitriol being distilled, M. Bernhard has observed it to continue emitting vapours in this manner for the space of ten days. When the vessels are quite cold, the receiver must be opened carefully, so that none of the luting may fall into it. After which the fluid contained in it is to be poured into a bottle, and the air carefully excluded. The fluid that is thus obtained, is the ordinary oil of vitriol, of which Bernhard got sixty-four pounds from six hundred weight of vitriol; and on the other hand, when no water had been previously poured into the receiver, fifty-two pounds only of a dry concrete acid.

The vitriolic acid made in these kingdoms is produced by the combustion of sulphur. There are three conditions requisite in this operation. Vital air must be present, to maintain the combustion; the vessel must be close, to prevent the escape of the volatile matter which rises; and water must be present to imbibe it. For these purposes, a mixture of eight parts of sulphur with one of nitre is placed in a proper vessel, enclosed within a chamber of considerable size, lined on all sides with lead, and covered at bottom with a shallow stratum of water. The mixture being set on fire, and shut up, will burn for a considerable time, by virtue of the supply of vital air which nitre gives out when heated; and the water imbibing the sulphureous vapours, becomes gradually more and more acid, after repeated combustions, and the acid is afterwards concentrated by distillation.

The vitriolic acid is considerably denser than any other acid or transparent fluid, and in general its affinities are stronger. It strongly attracts water, which it takes from the atmosphere very rapidly, and in large quantities, if suffered to remain in an

open vessel. If it be mixed with water it produces an instantaneous heat equal to that of ebullition.

Pure vitriolic acid is colourless, and emits no fumes. When it is heated it becomes more and more concentrated by the loss of a portion of water, which rises before the acid itself. No permanently elastic fluid or air is obtained from the vitriolic acid by mere heat in the common method, but the addition of any combustible substance causes it to become of a dark or brown colour, more especially if the substance be either an animal or vegetable product; at the same time that vitriolic acid air is emitted, which is of the same nature as the fumes of burning sulphur. For the production of this air, it is necessary that but a small quantity of oil, or any other very combustible substance, should be added at a time; because otherwise the acid would be thrown out of the vessel by the violence of the ebullition. The most elegant method of procuring vitriolic air consists in boiling a small quantity of mercury in the concentrated acid. Several of the other metals produce the same effect. With iron the greatest part of the elastic product consists of vitriolic air, and the rest, which is about one fifth, is inflammable. This last product is less in quantity, the more concentrated the acid. Zinc affords vitriolic air, together with a quantity of inflammable air, amounting to near two thirds of the product. The whole produce with copper is vitriolic acid air. Silver likewise affords this elastic product alone. Lead yields but a small quantity of vitriolic air, which has nothing inflammable in it. Neither gold nor platinum afforded any air; the acid acting upon neither of them. The gold however rendered the acid of a yellowish colour, probably in consequence of a minute quantity of impurity*.

Vitriolic acid air is imbibed by water, in the quantity of about ninety times the bulk of the water; and it is remarkable that it is not expelled by freezing, like all other kinds of air. The ice of this water sinks to the bottom, a circumstance for which Dr. Priestley does not offer to account, but which seems to explain in some measure the difficulty attending the expansion of common water by freezing, though the general operation of cold diminishes the bulks of bodies: for it seems reasonable to infer, that the ice of water would in all other cases, as well as the present, be heavier than water in the fluid state, if it were not for its aerial contents, which assume the elastic form.

Vitriolic acid air is perfectly transparent, and, when confined by quicksilver, its dimensions are not liable to any variation, excepting by heat and cold, just like common air, provided there be no moisture in the receiving vessel, or in the mercury. It instantly extinguishes flame, and destroys animal life. According to Mr. Kirwan's experiments, it is more than twice as heavy as atmospheric air, being the heaviest of all the elastic fluids. From this cause it extinguishes a candle for many times successively, by dipping the flame into an open jar in which it has stood a full hour with its mouth exposed to the common air. Cold, or a diminution of temperature, does not occasion any greater diminution of its bulk than common air is subject to in the same circumstances.

When vitriolic acid air is mixed with alkaline air, a beautiful white cloud is formed by their combination, while both airs gradually assume the solid state, so that the mercury rises almost to the top of the vessel. The white cloud must of course consist of the salt called vitriolic ammoniac. If the acid air be poured to the alkaline air, the cloud is formed at the bottom, and gradually rises to the top; but if the alkaline air be poured in last of the two, the cloud immediately rises to the top.

* Priestley on Air, 1790, ii. 304.

These consequences naturally result from the alkaline air being the lightest of the two.

There was frequently an appearance of sulphur produced upon the mixture of alkaline air with vitriolic acid air; for the inside of the tube would be covered with a perfectly yellow matter: but this colour goes off in time, and nothing but a white saline substance remains. No remarkable appearance is produced upon the mixture of vitriolic acid air with other airs; but common air is injured by standing in contact with this elastic fluid. It is most probable that the vitriolic acid air became converted into common vitriolic acid by attracting vital air from the air of the atmosphere, which must consequently have been left in a less respirable state than before.

This acid air was not found by Dr. Priestley to be capable of dislodging the nitrous or marine acids from any of their bases which he tried; a circumstance doubtless depending on the phlogistication or want of vital air necessary to convert it into vitriolic acid. Oils imbibe this air pretty rapidly, in proportion to their tenacity, though they cannot be made to imbibe so much of it as water can.

Equal quantities of whale oil, olive oil, and oil of turpentine, being fully impregnated with this aerial fluid, the olive oil was rendered quite colourless and the whale oil became reddish, after having imbibed six or eight times their bulk of air. In this manner they continued in glass jars confined by quicksilver about a month, when the oil of turpentine was become of a beautiful amber colour, the olive oil darker, and the whale oil darker still. Their tenacity was not apparently increased, but their smell was extremely pungent by the escape of the acid air.

Vitriolic ether imbibes this acid air, almost as readily as water does; but its properties do not appear to be changed. Phosphorus gave no light in this air; but the upper surface of it turned black, and the surface of the quicksilver upon which it lay had a deep yellow or blackish kind of scum upon it, as if it had been in part dissolved by the acid. Liver of sulphur slowly absorbed a quantity of vitriolic acid air, without suffering any perceptible change in its properties. Very dry charcoal absorbed a quantity of vitriolic acid air, without producing any remarkable effect either in the remaining air or upon the charcoal, excepting that the latter had acquired a pungent smell. Vitriolic acid air dissolved camphor pretty well, and reduced it to a transparent liquor. Water being admitted to it, the camphor re-assumed its natural solid form, but seemed to have acquired acidity of taste.

When the electric spark is taken in this acid air, the inside of the glass tube in which it is confined is covered with a blackish substance, the air itself being diminished. In this experiment, the electric explosion is much more effectual than the same quantity of electricity in sparks. The black matter seems to be produced by a portion of the mercury which confines the vitriolic acid air, and is partly distributed through it, or dissolved in it. It is probable that part of the vitriolic acid combines with the mercury, and is precipitated with it in the form of globules of such extreme minuteness as to appear black. In what manner the electric shock operates, whether by entering into the combination, or by altering the specific heat of the compound, or simply by the concussion which may throw the particles suddenly within the sphere of attraction, cannot be well explained for want of a sufficient number of facts *.

Though the vitriolic acid does not emit any elastic fluid by the usual process of boiling in an open vessel, yet it appears to suffer some change in its component parts

* Priestley on Air, 1790, ii. 323.

when heated in a glass tube hermetically sealed and nearly exhausted. After the acid had been thus made to boil for some time, a dense white vapour appeared in quick motion at a distance above the acid; and though, on withdrawing the fire, that vapour disappeared, it instantly re-appeared on renewing the heat. When the tube was cool, it was opened under water, and a quantity of air rushed out, though the acid had been thus made to boil violently while it was closing, so that there could not have been much common air in the tube. This air was found to be rather better in point of respirability than common air; but Dr. Priestley does not appear to have examined its properties in other respects.

A quantity of dense vitriolic acid being boiled in a glass retort, and the vapour passed through a red hot earthen tube glazed inside and out, and filled with pieces of broken tubes, the liquor that distilled over was found to be the same thing with water impregnated with vitriolic acid air. The oil of vitriol used in this process was 714 grains, and the liquor collected was 154 grains. At another time, when 762 grains of oil of vitriol, of the specific gravity of 1856, was used, the quantity of volatile acid was 462 grains, of the specific gravity of 1340. In these processes a large quantity of dephlogisticated air was afforded of the purest kind, the quantity in the last experiment being 130 ounce measures*.

In these experiments the vitriolic acid appears to have been decomposed, and converted into volatile vitriolic acid and dephlogisticated air, which is generally admitted to be the principle of acidity. As sulphur is converted into vitriolic air by combustion, which vitriolic air produces the volatile or sulphureous acid by combination with water, and this likewise becomes converted into common vitriolic acid by exposure to the air, from which it doubtless attracts the vital part, as we have already observed to happen when vitriolic and common air are confined together; so, by a contrary gradation, it appears that the dense vitriolic acid being ignited by the contact of red hot earthen tubes, loses a part of its vital air, and becomes converted into volatile vitriolic acid, from which the vitriolic air may be expelled by heat, and in which the presence of sulphur may be exhibited when combined with alkaline air. It appears therefore that vitriolic air has the same relation to vitriolic acid, as nitrous air has to the acid of nitre. Both are capable of sustaining ignition without being decomposed, and are therefore separable by that process from the larger portion of vital air which they are capable of saturating at a lower temperature. Thus sulphur, ignited or burned, in contact with vital air attracts no more than produces the compound called vitriolic acid air, which afterwards, at a lower temperature, when united with water, becomes vitriolic acid, by attracting a larger portion of vital air from the atmosphere: and, on the contrary, vitriolic acid being ignited emits the redundancy of vital air, and becomes converted into vitriolic acid air.

It must be admitted, however, that we are far from clearly understanding the theory of processes of this nature, in which combinations and decompositions are apparently effected by mere heat. It is probable that, in many cases, we do not see the whole of the facts; it is certain that our imperfect acquaintance with the constituent parts of such apparently simple principles as sulphur and vital air must greatly diminish the accuracy of our inferences; and to this we may add that, in the various methods of changing the temperature of bodies in the solid, fluid, or elastic forms, there may be, and really do exist, differences, especially in the higher temperatures, which we either overlook, or cannot estimate with sufficient facility and exactness to infer all the consequences they may produce. It seems to arise from difficulties of this kind that

* Priestley, in *Philos. Transf.* vol. lxxix. page 290.

we cannot reconcile the following decomposition of vitriolic acid air, when long heated with water in perfectly closed vessels, with its permanency in the foregoing experiments.

Dr. Priestley exposed water, impregnated with vitriolic air, enclosed in glass tubes hermetically sealed, to a sand heat for many weeks. In three weeks the water had deposited a quantity of black powder, and a bit of matter exactly resembling sulphur. The process being continued for several months, crystals of sulphur were formed in the glass, which were tried by burning. Near half the common air in the tube, above the liquor, had disappeared, and the remainder was perfectly noxious. Dr. Priestley thinks that the volatile acid, in this expanded and confined state, uniting with the dephlogisticated air in the tube, first formed vitriolic acid, and that this acid uniting with the phlogiston formed the sulphur.

The vitriolic acid forms peculiar and well-known compounds with earths, alkalis, and metals. Siliceous earth does not appear to be affected by it. With argillaceous earth it forms alum. This salt has an austere or astringent taste; is soluble in about 15 times its weight of water at the temperature of 60° , and in a much less quantity at higher temperatures, from which it is separated in permanent or slightly efflorescent crystals. It is fusible in a moderate heat, and froths up till its water of crystallization is dissipated; at which period it has the form of a white friable substance called calcined alum, which retains the greatest part of its acid when not too much heated, and may be again restored to its original form by again adding the water of crystallization it had lost by the heat.

The acid in alum is not saturated. If a solution of alum be boiled upon clay, a considerable portion of the latter will unite with the salt, and form a combination which is much less soluble than the alum itself.

With calcareous earth, the vitriolic acid forms gypsum or plaster of Paris. This saline substance is plentifully found in nature, and is known by different names, according to its texture and external appearance. See GYPSUM. It is soluble in about five hundred times its weight of water at the temperature of 60° , and has for that reason been classed among earths.

With ponderous earth it forms the ponderous spar or marmor metallicum. With magnesia it forms Epsom salt, which is soluble in its own weight of water at the temperature of 60° , crystallizes by evaporation, and effloresces by exposure to a dry air.

The vitriolic acid in combination with vegetable alkali forms the salt usually known by the name of vitriolated tartar. This requires sixteen times its weight of water to dissolve it, and forms permanent hard crystals by evaporation.

Mineral alkali combined with this acid forms Glauber's salt, which requires only three times its weight of water to dissolve it at a mean temperature. It is much more soluble in hot than in cold water, and may therefore be separated from the hot saturated solution either by cooling or evaporation. Its crystals are usually large and well formed; but they lose their water of crystallization, which amounts to near half their weight, by exposure to the air, and fall into an efflorescence or white powder.

Vitriolic acid with volatile alkali forms vitriolic ammoniac. Twice its weight of cold, or an equal weight of hot water, is sufficient to dissolve it; and consequently it is separable either by cooling or by evaporation. Its crystals are permanent, or slightly disposed to attract moisture and deliquesce. Chemists differ with respect to its volatility; but it is probable that it cannot sustain any moderate heat without decomposition, either of its acid or alkali.

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The vitriolic acid acts upon and dissolves many of the metals, and forms combinations described under the respective titles of those metals.

In the distillation of the metallic and earthy salts, the last portions of this acid are decomposed by the heat like the nitrous; a product of vitriolic air and vital air being afforded, and in some cases actual sulphur. Decomposition or phlogistication of this acid likewise takes place when it is treated with combustible bodies. We have already seen, that in this combination there is an escape of vitriolic air or phlogisticated acid, doubtless attended with the addition of a portion of vital air to the combustible. In the dry way, when vitriolic salts are heated with charcoal, the escape of vitriolic air is much more speedy, abundant, and easy, because the attraction of the inflammable substance for the vital air of the acid greatly facilitates the disengagement of the vitriolic air, which consists of another portion of acid united with sulphur. And in this process, if sulphur consist, as stated by the theory of Stahl, of phlogiston and the acid of vitriol, the combustible body must have emitted phlogiston while it imbibed the vital air.

It is seen, therefore, that the vitriolic acid, originally produced by the combustion of sulphur, is again reduced to that substance by the action or effect of some other more combustible body, which may deprive it of vital air, and perhaps add the principle of inflammability, if such a common principle be admitted to exist. The modern discoveries on elastic fluids have exhibited a great variety of facts, which clearly indicate this leading circumstance of the acidification and reduction of this substance. In the earlier times of chemistry, this was with justice thought a discovery of the first magnitude, though effected in a less direct method. The greatest difficulty in the attempt naturally consisted in the volatile nature of the vitriolic acid, which being rendered still more so by the addition of any combustible body, would of course elude the endeavour to subject it to any considerable degree of heat; and the means of examining the volatile products were not then known. It was in all probability the former circumstance which led the great Stahl, the founder of the phlogistic theory, to direct his attention to the vitriolic combinations in which the acid is more fixed by its adhesion to a base. Vitriolated tartar, or fixed alkali, was the salt he chose. This consists of the vitriolic acid combined with fixed alkali; and still more to prevent the acid from rising when phlogisticated or changed by a combustible body, he added an equal weight of fixed alkali to the salt. This mixture he fused in a crucible, with half a part of powdered charcoal, and, after well stirring the whole together, and exposing it to a strong heat of short continuance, he poured it out all sparkling upon a greased stone. The compound was soluble in water, and proved to consist in a great measure of liver of sulphur, or the combination of sulphur and an alkali, contaminated indeed by a portion of charcoal held in solution. This liver of sulphur was accordingly dissolved in water, and by the addition of an acid the sulphur was separated from the alkali and fell down.

In these experiments it is evident that the charcoal converted the vitriolic acid into sulphur, or volatile vitriolic acid, which was detained by the redundant alkali, and that the acid, last added in the watery solution, caused a separation of the sulphur, by seizing the alkali in consequence of its stronger affinity.

The electric spark, passed between two surfaces of vitriolic acid confined in a glass tube, decomposes the acid. Vital air escapes, and the acid is rendered sulphureous or phlogisticated.

The sulphureous or volatile vitriolic acid forms combinations with earths, alkalis, and metals; but its attraction to these bases is exceedingly weak. Exposure to air for a length of time changes these salts into common vitriolic salts, doubtless in the

same manner as it converts sulphureous acid into common vitriolic acid; that is to say, by affording vital air, and perhaps by receiving phlogiston, as it may be dissipated.

For farther particulars respecting this acid, see SULPHUR; AIR, HEPATIC; AIR, DEPHLOGISTICATED; and the several metals.

ADAMANT. See DIAMOND.

ADAMANTINE SPAR. This stone, which comes to us from the peninsula of higher India, and also from China, has not engaged the attention of the chemical world till within a few years past. It is remarkable for its extreme hardness, which approaches to that of the diamond, and by virtue of which property it is used for polishing gems.

Two varieties of this stone are known in Europe. The first comes from China. It is crystallized, in six-sided prisms, without pyramids, whose length varies from half an inch to an inch, and thickness is about three quarters of an inch. Its colour is grey of different shades. The larger pieces are opaque; but thin pieces and the edges of the prisms are transparent. Its fracture is brilliant, and its texture spathose, which causes its surface to appear lightly striated. Its crystals are covered with a very fine and strongly adherent crust of plates of silvery mica mixed with particles of red felt-spar: A yellow superficial covering of martial vitriol was observed upon one specimen.

This stone is so hard that it not only cuts glass as easily as a diamond, but likewise marks rock crystal and several other hard stones. Its specific gravity is 3710.

Small crystalline grains of magnetical ferruginous calx are occasionally found in the adamantine spar of China, which may be separated by the magnet when the stone is pulverized.

The second variety, which comes from India, is called Corundum by the inhabitants of Bombay. It differs from the former by a white colour, a texture more evidently spathose, and lastly, because the grains of magnetical iron are smaller than in the former specimens, and are not interpersed through its substance, but only at its surface.

The chemical properties of this stone are very singular. It obstinately resists decomposition by any of the known methods. Mr. Klaproth submitted 300 grains of adamantine spar to fusion with 15 parts of mineral alkali, in a silver crucible, for twelve successive times, continuing each time for five hours as strong an heat as the vessel could support. After each fusion, he softened the mass with boiling distilled water, filtered it, and precipitated by acids the small portion of earth the alkali had dissolved; and lastly, he digested for several times, alternately, in concentrated and boiling acids, the portion which had not been decomposed.

In this long and painful method of treating the adamantine spar alternately with mineral alkali and concentrated acids he succeeded at length in decomposing it. This operation employed all his opportunities of leisure for more than three months, when he found the stone (exclusive of the magnetical calx of iron, which, without being one of the constituent parts of the spar, forms one fifth of its weight) to consist of clay two parts, united with one part of a peculiar earth whose nature is not yet determined*.

This earth is not siliceous, because, though insoluble in acids, it does not combine with fixed alkalis by fusion.

M. Morveau possesses two specimens of the adamantine spar found in France †:

* Klaproth in the Berlin Mem. for 1788, quoted in the *Annales de Chimie*, vol. i. † Ibid.

ADOPTER. A vessel with two necks placed between a retort and a receiver, and serving to increase the length of the neck of the former. *See APPARATUS.*

AFFINITY, CHEMICAL. *See ATTRACTION, ELECTIVE.*

AGARIC is a fungus growing on the trunk of the common larch tree, from which turpentine is extracted. Three fourths of its weight is a resinous substance, and the rest a slimy mucilaginous earthy matter, so tenacious as scarcely by any method to be dissolved in water.

AGATE. The oriental agate is almost transparent, and of a vitreous appearance. The occidental is of various colours, and often veined with quartz or jasper. It is mostly found in small pieces covered with a crust, and often running in veins through rocks like flint and petrosilex, from which it does not seem to differ greatly. When agates contain arborisations they are called mocha stone. These are considerably valued when the internal figure nearly resembles some animal or plant.

AGGREGATE. When bodies of the same kind are united, the only consequence is, that one larger body is produced. In this case, the united mass is called an aggregate, and does not differ in its chemical properties from the bodies from which it was originally made. Elementary writers call the smallest parts into which an aggregate can be divided without destroying its chemical properties, integrant parts. Thus the integrant parts of common salt are the smallest parts which can be conceived to remain without change; and beyond these, any farther subdivision cannot be made without developing the component parts, namely, the alkali and the acid.

AIR is the generic name for such invisible and exceedingly rare fluids as possess a very high degree of elasticity, and are not condensable into the liquid state by any degree of cold hitherto produced. This last circumstance is the only distinctive criterion between air and vapour; for vapor is condensable by cold. The air of the atmosphere was formerly thought to consist of one uniform fluid exclusively possessing the permanently elastic state; and in the few instances wherein the earlier chemists took notice of the elastic products of their operations, these products were usually supposed to consist of atmospheric air. Modern philosophers, among whom Dr. Priestley occupies the highest place, inasmuch that he may with justice be styled the father of this branch of natural philosophy, have discovered a considerable number of aerial fluids. These consist of, 1. Alkaline air. 2. Common or atmospheric air. 3. Dephlogisticated or vital air. 4. Dephlogisticated nitrous air. 5. Fixed air. 6. Fluor acid air. 7. Hepatic air. 8. Inflammable air. 9. Marine acid air. 10. Nitrous air. 11. Phlogisticated air. 12. Phosphoric air. 13. Vitriolic air.

AIR, ALKALINE. If the concrete volatile alkali, or common sal volatile of the shops, be heated, it assumes the elastic state, but consists either totally, or for the most part, of vapour, and not air. This vapour, or the salt itself, is a combination of pure volatile alkali and fixed air, and is quickly condensed in the solid form as before. If the same concrete salt be heated, either in solution with water, or with the addition of a small quantity of that fluid, the same disposition to sublime is exhibited, but the water detains the alkali, while the fixed air escapes, contaminated indeed with alkali, which rises afterwards. But when the caustic volatile alkali, which consists of the pure alkali itself dissolved in water, is heated, the alkali rises together with a much less quantity of water than is sufficient to hold it in solution in the dense fluid state. Part of this water impregnated with alkali is condensed in a small vessel interposed between the retort in which the caustic alkali is heated, and the mercurial apparatus over which the air is received. *See APPARATUS.* The rest

rest of the alkali passes forward in the permanently elastic state into an inverted jar over mercury.

As the procuring of alkaline air by heating the caustic volatile alkali is attended with all the expence of originally manufacturing the alkali from sal ammoniac, it soon occurred to the discoverer, Dr. Priestley, that this air might be more cheaply obtained by the original process with the sal ammoniac itself. This last fact consists of volatile alkali in combination with marine acid, and the method of disengaging the volatile alkali together with water only consisted formerly in distilling a mixture of sal ammoniac with three fourths of slaked lime. It will be seen that this mixture did not afford a sufficient quantity of water in the first stage, or indeed in any stage of the operation, to condense the whole of the alkali which was disengaged: for Dr. Priestley found that the greatest part of the product is in the permanently elastic state, and consequently was lost in the common operation.

The heat of a candle expels a prodigious quantity of alkaline air from this mixture; at the same time that the lime unites with the marine acid. It is necessary that alkaline air should be received over mercury, because it is readily absorbed by water, with which it forms the fluid called caustic volatile alkali, or commonly spirit of sal ammoniac with lime. Dr. Priestley found, by a rough trial, that ten parts by weight of water absorbed four of alkaline air, reckoning the ounce measure to weigh something more than half a grain, and the bulk of the water was increased by the addition of one fifth of its original magnitude. The absorption of alkaline air by water does not seem to consist of the whole of the fluid indiscriminately, for after the water ceases to imbibe alkaline air which has stood for a considerable time upon it, it will imbibe other alkaline air newly produced. The purest and strongest fluid volatile alkali is obtained by saturating water with this air; for which purpose the apparatus of Woulfe is peculiarly advantageous.

Caustic fixed alkali affords no elastic fluid by heat, the vapour expelled from it being nothing but water.

When a mixture of alkaline and marine acid air is made over mercury, a beautiful white cloud is formed, and a quantity of the elastic fluid disappears; at the same time that a solid white salt is formed by the subsidence of the cloud, which was found to be common sal ammoniac, or the marine acid united to the volatile alkali. The smell and the permanency of this white salt differs according to the redundancy of either of the airs in its composition. The common sal ammoniac is obtained when both are in due quantity; but, if either prevail, the compound is much more disposed to evaporate.

Nitrous air admitted to alkaline air likewise occasioned a whitish cloud, and part of the air was absorbed; but it presently grew clear again, leaving only a little dimness on the sides of the vessel. It is probable that the alkaline air united with some nitrous vapour or acid which might be present in the mixture; for, when water was admitted, the alkaline air was absorbed, and the nitrous air remained in possession of its peculiar properties.

Fixed air admitted to alkaline air formed oblong and slender crystals, which crossed one another, and covered the sides of the vessel in the form of net work. These must have consisted of the common or concrete volatile alkali, though perhaps with a redundancy of either principle according to its abundance in the mixture.

Inflammable air exhibited no particular appearance when mixed with alkaline air. Water, as in the former experiment, absorbed the alkaline air, and left the inflammable air as it was before. It was remarkable, however, that the water which was

admitted to them became whitish, and that this white cloud settled in the form of a white powder to the bottom of the vessel. Dr. Priestley does not appear to have examined its properties, perhaps because its quantity was too small.

Common air and alkaline air standing together for several days, and afterwards separated by the addition of water, which absorbed the latter fluid, did not appear to have any action upon each other, at least as far as was indicated by the test of nitrous air: for the common air was as much diminished in this way of trial after the operation as before.

Phlogisticated air, or common air which had been diminished by standing over a mixture of iron filings and sulphur, was likewise unchanged by mixture with alkaline air: for when this last was absorbed by water, the remaining phlogisticated air was equally unchanged by the test of nitrous air.

Spirit of wine imbibes alkaline air as readily as water, and seems to be as inflammable afterwards as before. Alkaline air contracts no union with this aerial fluid; but oil of turpentine and essential oil of mint absorbed a very small quantity of it, without however having suffered any perceptible change in their properties. Ether imbibed alkaline air pretty freely, without any change of colour or diminution of its inflammability. It also evaporated as readily as before; but Dr. Priestley did not ascertain this last fact with particular attention.

Sulphur, nitre, common salt, and flints, were put to alkaline air without imbibing any part of it; but charcoal, sponge, bits of linen cloth, and other substances of the same kind, seem to condense this air upon their surfaces. A piece of the inspissated juice of turnsole being made very dry and warm, absorbed a great quantity of this air, by which it contracted a most pungent smell, but its colour was not changed.

Alum undergoes a very remarkable change by the action of alkaline air. It becomes opaque progressively from the surface inwards, and in this state perfectly resembles alum which has been roasted. Dr. Priestley imagines that the alkaline air seizes upon the water that enters into the constitution of crude alum, and which would have been expelled by heat; but as roasted alum likewise imbibes alkaline air, it seems most probable that this last substance unites with the redundant portion of acid which that salt contains.

Phosphorus gave no light in alkaline air, and made no lasting change in its dimensions. It varied indeed a little, being sometimes increased and sometimes diminished; but after a day and a night it was in the same state as at first. Water imbibed this air just as if nothing had been put to it.

Copper wire was not affected by remaining several hours in alkaline air, a circumstance probably owing to the want of vital air to calcine the metal, as it is found in the processes with this metal and volatile alkali that such calcination is necessary in order that a mutual combination may take place.

Marine acid absorbed alkaline air, and formed a little of the white ammoniacal salt, such as was afforded when the marine acid air and the aerial fluid are mixed. A little remained unabsorbed and transparent, but upon the admission of common air to it, it instantly became white. Vitriolic acid also formed a white salt with alkaline air, and this did not rise in white fumes.

Alkaline air is slightly inflammable, though it extinguishes a candle dipped into it repeatedly; but at each time the flame was considerably enlarged by the addition of another flame of a pale yellow colour, and the last time this light flame descended from the bottom of the vessel to the top. These successive differences in the appearance seem to depend upon the admixture of the common air which assisted the inflammation.

Dr.

Dr. Priestley ascertained that alkaline air is heavier than common inflammable air, by putting a quantity of the latter into a vessel, and then adding half the quantity of alkaline air, and to this a like quantity of marine acid air. The white cloud was formed as usual, but it did not rise within the space occupied by the inflammable air; so that the inflammable air had kept its place above the other without mixing with it. That the alkaline air is lighter than the acid air is shewn from the formation of the cloud on their mixture; for it begins at the bottom, and gradually reaches the top, when the acid air is last added; but when the acid air is put to the alkali, the whole becomes cloudy immediately quite to the top of the vessel.

Alkaline air, which, according to the general law of vaporous or elastic fluids, becoming condensed, produces heat when dissolved in water, produces, on the contrary, cold when it is added to ice. The ice becomes very speedily fluid, and doubtless, by its obtaining the fluid state, absorbs more heat than the condensation of the air is capable of affording.

When acid and alkaline airs are mixed over mercury, the quantities of acid air absorbed are various, according to the several kinds made use of. Of marine acid air and alkaline air equal bulks disappear by mutual combination. Two measures of alkaline air saturate one of vitriolic. The same proportion is observed between alkaline and fluoracid air. Fixed air does not remarkably differ from this last proportion. The red vapour of nitrous acid seems to require about five times its bulk of alkaline air to saturate it; but in this there is much uncertainty on several accounts.

The electric spark or shock taken in alkaline air has a red colour similar to that which it has in inflammable air; and this treatment causes the air to expand at length to about three times its former bulk, at the same time that it becomes no longer absorbable in water. Ignition of a glass retort containing alkaline air likewise rendered it permanent over water and inflammable; and the same effect was produced by heating pieces of crucible or porcelain in alkaline air by a burning glass, and also by passing the alkaline air through an ignited earthen tube.

It remained to be determined in what manner this change in the alkaline air took place. For this purpose Dr. Priestley, whose experiments and discoveries have supplied the whole of the preceding part of this article, heated several of the metallic calces in alkaline air, with a view to reduce them to the metallic state, as he had before done by the same process with inflammable air. Massicot, or the calx of lead, was first tried. The lead was revived, and the residue of the air was the fluid called phlogisticated air. Hence it should seem, if we might speak of phlogisticated air and inflammable air as simple substances, that the alkaline air consists of an intimate combination of both; that this union is destroyed by electricity, which of course must enlarge the bulk of the whole, because disengaged inflammable air has a much less density than any other aerial fluid. The quantity of lead in these experiments was always less than a bulk of inflammable air equal to that of the alkaline air would have reduced: from which circumstance, as the alkaline air was convertible into an inflammable fluid of three times its original bulk, the Doctor is disposed to think that the phlogisticated air contains a very considerable portion of phlogiston or inflammable matter which might else have reduced a larger portion of metal. But as the general tenor of his conduct has ever been unprejudiced by theory, he does not disguise the facts, that the inflammable air from alkaline air may not be the same as that procured by the action of acids upon metals, and that some of the massicot used in these experiments was capable of affording fixed air by heat. This

last substance, when expelled, would unite with some of the air, and precipitate it in the form of the concrete alkali; and to this I would likewise add, that it may easily be supposed that the effect of the calx in attracting inflammable air may be considerably less when an intimate combination, such as the volatile alkali, is to be destroyed, than when the inflammable air is presented alone and disengaged, and consequently that less of the lead would be revived in the former, than the latter case. It may be observed, that the conclusions are nearly the same, whether we suppose the inflammable air as phlogiston to have combined with the calx itself, or whether we suppose it to unite with the vital air of the calx, and reduce it by depriving it of that substance.

Glass of antimony absorbed part of the alkaline air when it was heated by the burning glass in that fluid, and there was an appearance of metallic globules. The Doctor could not obtain the same appearance in inflammable air.

When scales of iron were heated in alkaline air, the quantity of the latter was much increased, and became strongly inflammable. No water was afforded in this process. The iron was revived, being perfectly soluble in diluted vitriolic acid, and had lost one grain in twenty-four. In this experiment, the heat necessary to revive the iron appears to have been sufficient to decompose more of the alkaline air, than was necessary to revive the iron.

Red precipitate was heated in the same manner in alkaline air. The consequence was, that the mercury was revived, and at the same time a considerable quantity of water was produced: the residual air contained a portion of vital air. In another experiment, the quantity of dephlogisticated air was still more considerable; and in a third, an explosion took place. It appears, therefore, that in these experiments the mercury was reduced by the mere heat, a thing well known to be practicable; that vital air was expelled from the mercurial calx, as is usual in such reductions; that the heat was sufficient to convert part or the whole of the alkaline air into inflammable and phlogisticated airs; that the vital air had remained unchanged in mere mixture with the principles of the alkaline air, when the heat had been moderate; but that in the case of the explosion the heat had probably been such as to cause the ignition and sudden combination of the vital and inflammable airs; and lastly, that the water which appeared and was deposited from the airs was a consequence of their combination, whether it be supposed to be really composed of inflammable and vital air, or only separated from them when they unite to form nitrous acid, fixed air, or any other substance. See WATER.

Scheele has observed, that volatile alkali is decomposed when kept a long time in digestion with the nitrous acid and manganese, or when sal ammoniac is distilled from the same metallic calx. He remarks likewise that volatile alkali is decomposed by the calx of gold, mercury, and other metals. In these several decompositions he obtained phlogisticated air, which he observes in general is afforded whenever the phlogiston of volatile alkali, which he takes to be one of its component parts, is attracted by any other body. Bergman concludes, from his own experiments upon fulminating gold, as well as from those of Scheele, that the volatile alkali contains phlogiston, and that whenever this principle is taken from it by virtue of a superior attraction, an elastic fluid is disengaged, which probably constitutes the other principle of the volatile alkali. Mr. Kirwan likewise observes, in his notes on the treatise of Scheele upon air and fire, that the calx of gold takes phlogiston from the volatile alkali, at the same time that a kind of air is suddenly formed, which from its properties, as discovered by Scheele, appears to be phlogisticated air.

From

From reflecting on these general facts, the excellent Berthollet entertained an expectation of arriving at a more accurate knowledge of the nature of volatile alkali, and by that means explaining a number of natural operations, in which this alkali is either formed or destroyed *.

He first endeavoured to determine the products obtained from ammoniacal nitre, or the combination of nitrous acid and volatile alkali. For this purpose he distilled two ounces of the dry salt in a small glass retort, from which proceeded a recurved tube, communicating in the manner of figure 2, with a bottle surrounded with ice, for the purpose of condensing aqueous vapours or acid. For greater security, another of these bottles was interposed between the retort and a jar, inverted over water, and designed to receive the aerial products. By heat carefully applied the whole was distilled, excepting one gros of ammoniacal nitre which was not decomposed. During the operation, a large quantity of dephlogisticated nitrous air was disengaged, which Mr. Berthollet considers as nitrous air, containing a small portion of vital air; and in the two vessels surrounded with ice was contained one ounce and forty-three grains of a fluid considerably acid. This liquor was distilled on a water bath. Four gros thirty-two grains of ammoniacal nitre, which had been volatilized in the preceding distillation, now remained in the retort; and the acid liquor which came over was then saturated with vegetable alkali without affording the smallest indication of the presence of volatile alkali. Lastly, he evaporated this saturated liquor on a water bath, and obtained nothing but pure water, with fifty-four grains of nitre left behind in the retort, which, according to Bergman's valuation, would contain nearly twenty-seven grains of alkali, nine grains of water, and eighteen of pure acid. Hence he states the products of the two ounces to be, exclusive of what remained in the retort at the first distillation,

Liquor contained in the bottles	-	-	1 ounce 43 grains,
Ammoniacal nitre contained in the liquor	4 gros	32 grains,	
Nitrous acid contained in the same liquor		18 grains,	
And consequently water formed	-	-	3 gros 65 grains.

From this deduction, on which many remarks might be made, he concludes that aqueous inflammable air (taking the composition of water as an admitted fact) is one of the principles of volatile alkali.

This ingenious chemist having ascertained that the aerated or dephlogisticated marine acid contains vital air, and that the caustic volatile alkali unites with this acid with an effervescence and disengagement of phlogisticated air, at the same time that the volatile alkali is no longer found, concludes that the inflammable air of the alkali forms water by uniting with the vital air of the acid, and consequently that the other principle of the volatile alkali must be phlogisticated air. In confirmation of this, he quotes the experiments of Priestley which we have already recited, wherein water was produced by heating metallic calces in vital air. He likewise states an experiment of his own to the same effect. Copper was dissolved in the volatile alkali, and the dried salt was exposed to distillation. The product was water and phlogisticated air, and the copper was completely revived. A portion of the volatile alkali came over without decomposition, which likewise held a small portion of copper in solution.

The properties of fulminating gold, which have astonished and embarrassed the chemical world for a long time, have been happily brought in confirmation of this theory. M. Berthollet had the courage to distil the volatile alkali from this combi-

* Memoirs of the Parisian Acad. for 1785.

nation. This is disengaged from the calx without decomposition, when the heat is very moderate and carefully managed. He likewise detonated seven grains of fulminating gold in a retort, and collected the air, which proved to be phlogificated air. It is not easy to imagine how so considerable a quantity of this dangerous composition could be exploded in any apparatus calculated to collect the air without being attended with a certainty of its flying in pieces. This was however accomplished by the simple contrivance of including a quantity of water, which had been deprived of its air by boiling, along with the fulminating gold. The mouth of the retort was left open, and the water kept boiling until it had entirely evaporated; consequently the internal part of the retort contained only steam or aqueous vapour, until the instant that its bottom became dry and the explosion took place. The aerial product was then taken out by plunging the retort into water. It was proved to be phlogificated air by the test of electricity, which diminished it when mixed with inflammable air. This philosopher proceeded to determine the proportions of inflammable and phlogificated air which enter into the formation of volatile alkali. From the weight of volatile alkali supposed to be contained in fulminating gold, and taken to be equal to the excess of weight of this precipitate beyond that which is afforded by fixed alkali, together with other data equally indirect, he had formerly concluded that the inflammable air amounted to one sixth of the weight, or two thirds of the bulk of volatile alkali. He afterwards proceeded to avail himself of the more direct method of electricity and the subsequent explosion. In this way, by making the experiment with every precaution, he found that seventeen parts of alkali received an augmentation of bulk equal to sixteen. This was introduced into the eudiometer of Volta by successive portions, together with a due quantity of vital air; the whole amounting to five measures of the latter, and four measures of the electrified alkaline air.

These nine measures were reduced to $4\frac{1}{10}$, so that there were $4\frac{4}{10}$ destroyed. Care was taken in this experiment to add a surplus of vital air, for the greater certainty of destroying the whole combustible part. But he states it as a known fact, that combustion causes nearly 14.5 measures of inflammable air to disappear, together with 74 parts of vital air. Whence it follows that the $4\frac{4}{10}$ destroyed represent $2\frac{2}{5}$ of inflammable gas, and $1\frac{1}{10}$ of phlogificated air, it being ascertained from his other experiments that the part which is not combustible consists of that fluid. And admitting the weight of phlogificated air to be eleven times that of an equal bulk of inflammable air, the weight of this last contained in volatile alkali, compared with that of the phlogificated air, will be as 29 to 121.

These facts are applicable to a variety of phenomena, in which volatile alkali has unexpectedly made its appearance. When a few ounces of powdered tin are mixed with moderately strong nitrous acid, and, after they have stood together a minute or two, about half an ounce of fixed alkali is added to them, a very pungent smell of volatile alkali is immediately perceived. The experiment succeeds equally with lime instead of alkali, and may be accounted for by considering that the nitrous acid being deprived of its vital air, its remaining principle, namely phlogificated air, would be set at liberty, if the inflammable air extricated from the tin were not at hand to combine with it and form volatile alkali. And the explanation will be the same, whether the metal be supposed to emit its phlogiston in the form of inflammable air, or the water to be decomposed into its principles of vital and inflammable air, in which case the former will enter into the calx together with the vital air of the nitrous acid. The subsequent addition of the fixed alkali or of the lime serves

serves only to disengage the volatile alkali from the mixture, and render it more immediately obvious to the senses.

From this and many other experiments it appears, that the component parts of volatile alkali are readily united when they meet together in the condensed state, though no means have yet been devised to combine them when in the elastic state. This last difficulty seems to depend on the resistance which one or both of them make to quitting the elastic state; whether such resistance depend upon the matter of heat in combination, the distance of the particles in this expanded situation, or any other circumstance hitherto unexamined.

Whenever iron rusts in contact with water, there is an extrication of inflammable air; and if iron filings moistened with distilled water be enclosed in a proper vessel together with phlogisticated air, there is a production of volatile alkali, as is shewn by the change of colour sustained by a piece of paper stained with the rind of blue radish, and included within the glass. This takes place in the course of twenty-four hours; but the change is much more rapid when nitrous air is used instead of phlogisticated air. Volatile alkali is generated and the nitrous air is converted into dephlogisticated nitrous air, which Dr. Austin*, with many other chemists, supposes to consist of nitrous air deprived of a portion of phlogisticated air, or, which is the same thing, possessing a surplus of vital. But if so, why should it not contain nitrous acid? See ACID, NITROUS, page 38.

AIR, ATMOSPHERICAL, or COMMON. The immense mass of permanently elastic fluid which surrounds the globe we inhabit must consist of a general assemblage of every kind of air which can be formed by the various bodies that compose its surface. Most of these, however, are absorbed by water, a number of them are decomposed by combination with each other, and some of them are seldom disengaged in considerable quantities by the processes of nature. Hence it is that the lower atmosphere consists of vital air mixed with phlogisticated air, together with moisture and the occasional vapors or exhalations of bodies. The upper atmosphere seems to be composed of a large proportion of inflammable air, a fluid of so much less specific gravity than any other, that it must naturally ascend to the highest place, where being occasionally set on fire by electricity, it appears to be the cause of the aurora borealis and fire-balls. It may easily be understood, that this will only happen on the confines of the respective masses of common atmospherical air, and of the inflammable air; that the combustion will extend progressively, though rapidly, in flashings from the place where it commences; and that when by any means a stream of inflammable air, in its progress towards the upper atmosphere, is set on fire at one end, its ignition may be much more rapid than what happens higher up, where vital air is wanting, and at the same time more definite in its figure and progression, so as to form the appearance of a fire-ball.

That the air of the atmosphere is so transparent as to be invisible, except by the blue colour it reflects when in very large masses, as is seen in the sky or region above us, or in viewing extensive landscapes; that it is without smell, except that of electricity, which it sometimes very manifestly exhibits; altogether without taste, and impalpable; not condensable by any degree of cold into the dense fluid state, though easily changing its dimensions with its temperature; that it gravitates and is highly elastic, are among the numerous observations and discoveries which do honour to the sagacity of the philosophers of the last century. They likewise knew that this fluid

* Phil. Trans. vol. lxxviii. p. 384.

is indispensably necessary to combustion ; but no one except the great, though neglected, John Mayow, appears to have formed any proper notion of its manner of acting in that process.

The air of the atmosphere, like other fluids, appears to be capable of holding bodies in solution. It takes up water in considerable quantities, with a diminution of its own specific gravity ; from which circumstance, as well as from the consideration that water rises very plentifully in the vaporous state, in vacuo, it seems probable that the air suspends vapor, not so much by a real solution, as by keeping its particles asunder, and preventing their condensation. Water likewise dissolves or absorbs air.

Mere heating or cooling does not affect the chemical properties of atmospherical air ; but actual combustion, or any process of the same nature, converts it into phlogificated air. Whenever a process of this kind is carried on in a vessel containing atmospherical air, which is enclosed either by inverting the vessel over mercury, or by stopping its aperture in a proper manner, it is found that the process ceases after a certain time ; and that the remaining air, which is about three fourths of the whole bulk, is of such a nature as to be incapable of maintaining any combustion for a second time, or of supporting the life of animals. From these experiments it is clear, that one of the following deductions must be true : 1. The combustible body has emitted some principle, which, by combining with the air, has rendered it unfit for the purpose of farther combustion : Or, 2. It has absorbed part of the air which was fit for that purpose, and has left a residue which was of a different nature : Or, 3. Both events have happened ; namely, that the pure part of the air has been absorbed, and a principle has been emitted which has changed the original properties of the remainder.

The facts must clear up these theories. The first induction cannot be true, because the residual air is not only of less bulk, but of less specific gravity than before. The air cannot therefore have received so much as it has lost. The second is the doctrine of the philosophers, who deny the existence of phlogiston on a principle of inflammability ; and the third must be adopted by those who maintain that such a principle escapes from bodies during combustion. This residue was called phlogificated air in consequence of such an opinion.

In the opinion that inflammable air is the phlogiston, it is not necessary to reject the second inference, that the air has been no otherwise changed than by the mere subtraction of one of its principles : for the pure or vital part of the air may unite with inflammable air supposed to exist in a fixed state in the combustible body ; and if the product of this union still continues fixed, it is evident that the residue of the air after combustion will be the same as it would have been if the vital part had been absorbed by any other fixed body. Or, if the vital air be absorbed while inflammable air or phlogiston is disengaged, and unites with the aeriform residue, this residue will not be heavier than before, unless the inflammable air it has gained exceeds in weight the vital air it has lost ; and if the inflammable air falls short of that weight, the residue will be lighter.

It seems most probable that the air of the atmosphere consists of a vital and a noxious part, from the fact that, when fixed bodies have been burned or calcined (for example, mercury converted by heat into precipitate per se), the vital air may be again extricated from them. This, instead of being mere atmospherical air, is found to be much more effectual for maintaining combustion, and is almost totally absorbed in that process, instead of leaving a residue supposed to be changed by phlogification. Hence therefore it may be inferred, that the air called phlogificated air does not in

fact receive phlogiston or any principle in combustion; because, if such a principle were emitted, it must in some way appear in the second combustion with vital air. And, on the other hand, there is no proof that phlogisticated air consists of respirable or vital air thus changed; for there is no unequivocal experiment to shew that this kind of air can by any means be obtained from the part or residue supposed to be phlogisticated.

We have frequently, however, found occasion to repeat the observation, that the theories of chemistry which are carried farther than experiments have yet proceeded, may all be applied without manifest contradiction in the explanation of the phenomena; though the simplest inductions are certainly to be preferred, because the most readily understood, the most probable, and the most easily rectified by new facts when they come to be discovered.

The general facts are, that combustible bodies take vital air from the atmosphere, and leave three fourths of phlogisticated air; and that when these two fluids are again mixed, in the proportion of one fourth of vital with three fourths of phlogisticated air, they compose a mixture not differing from atmospherical air by any test hitherto discovered.

The respiration of animals produces the same effect on atmospherical air as combustion does, and their constant heat appears to be an effect of the same nature. When an animal is included in a limited quantity of atmospherical air, it dies as soon as the air is vitiated, and no other air will maintain animal life but that which maintains combustion; that is to say vital air, or a mixture which contains it. Pure vital air maintains the life of animals much longer than atmospherical air.

There are many provisions in nature by which the proportion of vital air of the atmosphere, which is continually absorbed in respiration and combustion, is again restored to that fluid. In fact there appears, as far as an estimate can be formed of the great and general operations of nature, to be at least as great an absorption of the phlogisticated air and emission of vital air as is sufficient to keep the general mass of the atmosphere at the same degree of purity. Thus in volcanic eruptions there seems to be at least as much vital air emitted or extricated by fire from various minerals as is sufficient to maintain the combustion, and perhaps even to meliorate the atmosphere. And in the bodies of plants and animals, which appear in a great measure to derive their sustenance and augmentation from the atmosphere and its contents, it is found that a large proportion of phlogisticated air exists. Most plants emit vital air in the sunshine, from which it is highly probable that they imbibe and decompose the air of the atmosphere, retaining its noxious part, and emitting the vital part. Lastly, if to this we add the decomposition of water, which, though a contested point, is far from being disproved, there will be numerous occasions in which this doctrine will supply us with disengaged vital air; while by a very rational supposition its inflammable part may be considered as having entered into the bodies of plants for the formation of oils, sugars, mucilages, &c. from which it may be again extricated.

To determine the respirability or purity of air, it is evident that recourse must be had to its comparative efficacy in maintaining combustion, or any other equivalent process. Among these processes the acidification of nitrous air is one of the most elegant and effectual. This aerial fluid (*see* NITROUS ACID, page 38) is not rapidly imbibed by water, and may therefore, for temporary use, be received over it. Dr. Priestley found, by a variety of experiments, that when nitrous air and any other air are mixed, they undergo no change, if the latter be totally unfit to support

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combustion

combustion or animal life; but if the contrary, the red cloud is formed, and the whole bulk of the mixture is diminished by a quantity which is so much the greater, accordingly as the air in question is of a quality more suited to those purposes. This diminution he likewise proved to consist of a proportional part of the air which is tried, together with as much of the nitrous air as is required to produce the effect; so that if the nitrous air be duly proportioned to the effect it will wholly disappear.

The trial of the purity of common air by means of nitrous air has not however been found to exhibit such remarkable differences between the air taken up at various places as their known salubrity or unhealthiness might have afforded reason to expect. Two reasons may be offered to account for this. The first is, that a small difference in the purity of the air of a place may have a considerable effect on the health of those who are obliged to breathe it for a long succession of time: the second is, that the effects of nitrous air being the same upon all elastic fluids which contain equal proportions of vital air, however greatly their other component parts may differ, it will only be shewn that the airs are equally salubrious, as far as depends on their proportion of vital air, though they may be by no means so with regard to their noxious parts.

There are several ingenious contrivances called *EUDIOMETERS* (which see) for the mixing of nitrous and other airs, and measuring their diminution. As these however may not be easily procured in particular situations, and more especially as Dr. Priestley, whose experience is greater than that of any other philosopher, does not use them, it seems preferable to describe his method instead of any other in this place.

He first provides a phial containing about an ounce of water, which he calls the air measure. This he fills with air, by having first filled it with water, and placed it over the funnel in the shelf of his pneumatic apparatus, fig. 3, and when it is filled he slides it along the shelf, always observing that there be a little more air than is wanted. The phial being thus exactly filled with the air he is about to examine, and care being taken that it be not warmed by holding in the hand, he empties it into a jar of about an inch and a half in diameter, and then introduces to it the same measure of nitrous air, and lets them continue together about two minutes. The doctor chooses to have an overplus of nitrous air, that he may be sure that its effect may be the utmost possible. If he finds the diminution of these two measures to be very considerable, he introduces another measure of nitrous air; but the purest vital air will not, he believes, require more than two measures of nitrous air.

Sometimes he leaves the common and nitrous air in the jar all night, or a whole day; but he always takes care, whenever he compares two kinds of air, that both shall remain the same time in the vessels before he notes the degree of diminution.

When the preceding part of the process is over, he transfers the air into a glass tube about three feet long, and one third of an inch wide, carefully graduated according to the air measure, and divided into tenths and hundredth parts, so that one of the hundredth parts will be about one sixth or one eighth of an inch. Then immersing the tube in a trough of water, so that the water in the inside of the tube shall be on a level with the water on the outside, he observes the space occupied by the aerial mixture, and expresses the result in measures and decimal parts of a measure according to the graduation of the tube.

Thus if one measure of nitrous air be added to one of another aerial fluid, and the remaining mixture after diminution be $1\frac{2}{3}$ measure, he says, in short, that the measure

measure of the test was 1.26. But if two measures of nitrous air be added, he is careful to mention that circumstance.

It is some trouble to graduate a tube in this manner; but when it is once done the application of it is extremely easy. As it seldom happens that a glass tube is of an equal diameter throughout, the doctor generally fills that part of the tube which contains one measure, with quicksilver; and then dividing the quicksilver into ten parts by weight, he puts them again separately into the tube in order to mark the primary divisions. The weighing is rendered very easy by the help of a glass tube drawn to a fine orifice, which serves to take up a small quantity at a time as may be required in making the adjustment.

Common or atmospherical air loses about one fourth of its bulk by any process equivalent to combustion. This also happens when it is mixed with a quantity of nitrous air not greater than sufficient to saturate it. In this case the nitrous air totally disappears, as is proved from the observation that, when a small quantity of nitrous air is added to a large quantity of atmospherical air, the remainder is always less than the original quantity of atmospherical air; but, on the contrary, the smallest quantity of atmospherical air added to a large quantity of nitrous air always makes some addition to its bulk, notwithstanding the diminution which is sustained by the whole mixture.

The electric spark repeatedly taken in common air diminishes it at least as much as any other kind of combustion. Nitrous air is produced in this process (*see* page 33) by the union of the vital and phlogisticated airs, which is in fact the combustion of the latter. For this reason the experiment does not serve to shew that the electric spark itself is any thing more than disengaged heat, if indeed heat be a separate substance.

AIR, FIXED. The acid which is commonly known by the name of fixed air, abounds in great quantities in nature, and appears to be produced in a variety of circumstances. It composes about one third of the weight of lime-stone, marble, calcareous spar, and other natural specimens of calcareous earth, from which it may be extricated either by the simple application of heat, or by the superior affinity of some other acid; most acids having a stronger action on bodies than this. This last process does not require heat, because fixed air is strongly disposed to assume the elastic state. Water, under the common pressure of the atmosphere, and at a low temperature, absorbs somewhat more than its bulk of fixed air, and then constitutes a weak acid. If the pressure be greater, the absorption is augmented. Heated water absorbs less; and if water impregnated with this acid be exposed on a brisk fire, the rapid escape of the aerial bubbles affords an appearance as if the water were at the point of boiling, when the heat is not greater than the hand can bear. Congelation separates it readily and completely from water; but no degree of cold or pressure has yet exhibited this acid in a dense or concentrated state of fluidity.

Fixed air is nearly twice as heavy as common air, and for that reason occupies the lower parts of such mines or caverns as contain materials which afford it by decomposition. The miners call it choke damp. The Grotto del Cano, in the kingdom of Naples, has been famous for ages on account of the effects of a stratum of fixed air which covers its bottom. It is a cave or hole in the side of a mountain, near the lake Agnano, measuring not more than eighteen feet from its entrance to the inner extremity; where if a dog or other animal that holds down its head be thrust, it is immediately killed by inhaling this noxious fluid.

Fixed air is emitted in large quantities by bodies in the state of the vinous fermentation (*see* FERMENTATION), and on account of its great weight it occupies the

apparently empty space or upper part of the vessels in which the fermenting process is going on. A variety of striking experiments may be made in this stratum of elastic fluid. Lighted paper, or a candle dipped into it, is immediately extinguished; and the smoke remaining in the fixed air renders its surface visible, which may be thrown into waves by agitation like water. If a dish of water be immersed in this air, and briskly agitated, it soon becomes impregnated, and obtains the vivid taste of Pyrmont water. In consequence of the weight of the fixed air, it may be dipped out in a pitcher or bottle, which, if well corked, may be used to convey it to great distances. The effects produced by pouring this invisible fluid from one vessel to another have a very singular appearance: if a candle or small animal be placed in a deep vessel, the former becomes extinct, and the latter expires in a few seconds, after the fixed air is poured upon them, though the eye is incapable of distinguishing any thing that is poured.

When vegetable substances are exposed to a strong heat in vessels partly closed, the volatile principles fly off; but combustion does not take place for want of air. The fixed residue is the inflammable substance called charcoal. For general purposes, wood is converted into charcoal by building it up in a pyramidal form, and covering the pile with clay or earth, leaving a few air holes, which are closed when the mass is perfectly lighted, and by that means the combustion is carried on in an imperfect manner. Common charcoal when exposed to heat in closed vessels gives out a small quantity of inflammable air, which seems extraneous to it; and if it be burned, it leaves a small portion of earth, fixed alkali, and other salts. The greater part of charcoal therefore consists of one inflammable substance: and it is found that if this be burned in a closed vessel over mercury with vital air, the product is fixed air, and nothing else, as is proved by the residue after the fixed air has been absorbed by caustic fixed alkali; for there is either no aerial residue, or the residue consists of vital air as pure as at first*.

Hence it follows, that fixed air consists of the inflammable matter of charcoal united to vital air. The antiphlogistian philosophers consider this matter as a peculiar combustible and acidifiable base, and thence infer the presence of charcoal in all cases where fixed air is extricated or produced; but, on the other hand, several of the phlogistians think themselves justifiable in concluding that fixed air is produced by the union of inflammable air with vital air, when either of them is in the nascent state or state of extrication.

When the electric spark † is passed through fixed air confined by mercury, the volume of air is augmented about one twenty-fourth part; and of this three fifths are absorbed by a solution of caustic alkali, and the remainder is inflammable. An eminent philosopher of the phlogistic opinion supposes this effect to arise from the decomposition of the fixed air, whose vital air, combining more intimately with part of the inflammable air, forms water, the residue of this last air being disengaged. But the chemist who made the experiment, accounts for it as follows, without supposing the fixed air to be decomposed. The air of the atmosphere and other elastic fluids are proved by experiment to be capable of retaining mercury in solution; so likewise in all probability does the fixed air; and they all retain much water. Whenever therefore the electric spark, by passing through this mixture of fixed air, mercury, and water, ignites a minute portion of it, the vital air of the water unites with and cal-

* Lavoisier in Mem. Acad. Par. for 1781, p. 449.

† This experiment, first performed by Mr. Priestley, i. 248, has since been repeated by Van Marum and others. The experiment of Mr. Monge, quoted by Kirwan in his Essay on Phlogiston, p. 193, second edition, is that spoken of in the text; and the opinions are those of Messrs. Kirwan and Monge.

cines the mercury, while the inflammable air of the water is set at liberty, and the fixed air, like other acids, unites to the mercurial calx, and falls down with it. He supposes from analogy, that the water in the fixed air increases its volume by rarefying, and that the abstraction of the water occasions a contraction, while the disengagement of the inflammable air produces a somewhat greater augmentation of bulks. In this way, supposing the water and mercury to be present in sufficient quantity, the whole of the fixed air may enter into a solid combination, and nothing remains but inflammable air. Additional experiments must however be made before either opinion can be established.

Fixed air does not appear to be strongly disposed to unite with argillaceous earth. Most clays however afford a small quantity of this fluid by heat; and the snowy white substance resembling chalk, and known by the name of *lac lunæ*, is found to consist of clay saturated with fixed air. A saline substance, consisting of two six-sided pyramids joined at one common base, weighing five or six grains, and of a taste somewhat resembling alum, was produced by leaving an ounce phial of water, impregnated with fixed air and a redundancy of earth of alum, exposed to spontaneous evaporation for some months.

Calcareous earth and fixed air have a strong attraction for each other. Most of the specimens of calcareous earth abound with this acid; and the immediate precipitation of lime from lime-water is the test of the presence of this acid.

Ponderous earth combines very strongly with fixed air. This compound has been found in England and elsewhere.

Magnesia unites readily to a large proportion of fixed air.

The usual method of procuring magnesia is by precipitation from a solution of Epsom salt, by adding an alkali which combines with the acid. When a mild fixed alkali is used, it is necessary that the saline solutions should be boiling hot, and the ebullition continued for a short time, in order to dissipate a portion of fixed air, which would hold part of the magnesia in solution. From this cause it is, that perfectly mild vegetable alkali affords no precipitate when added to a solution* of Epsom salt at the temperature of 60°. The mineral alkali, which contains less fixed air than the crystallized vegetable alkali, likewise affords but a small quantity of precipitate, unless heat be applied. Mild volatile alkali also possesses the property of affording no precipitate when added to a solution of Epsom salt in the cold. With a greater heat magnesia is separated, and at a boiling heat it is again taken up, most probably forming a triple salt composed of vitriolic acid united to volatile alkali and magnesia. The saline combination of magnesia and fixed air is separated in crystals from all these cold solutions by standing uncovered; during which time the fixed air which held the magnesia in solution is no doubt gradually dissipated. The crystals afforded when vegetable alkali is used are contaminated with vitriolated tartar, which separates at the same time: those obtained by mineral alkali are finer and purer; but the most beautiful and purest are obtained by leaving the solution to which volatile alkali has been added, exposed for some days in an oblong vessel.

This crystallized aerated magnesia has usually the form of six-sided prisms. It is almost tasteless; effloresces in the air; becomes pulverent by heat by the loss of

* One part Epsom salt, dissolved in six parts of water, was mixed with one part of crystallized vegetable alkali, dissolved in five parts water. Consult Fourcroy in the *Annales de Chimie*, ii. 282, from whence the whole of this article respecting aerated magnesia is taken.

its fixed air and water; is soluble in about forty times its weight of water, at the temperature of 55° . Half its weight consists of fixed air, one fourth water, and one fourth magnesia; whereas the common aerated magnesia obtained by rapid precipitation contains forty parts magnesia, forty-eight fixed air, and twelve water.

All the earthy combinations of fixed air are nearly insoluble in water; they are all more soluble with an excess of that acid than in mere water; and they all give out their fixed air by heat, except the native specimen of aerated ponderous earth. This last contains no water; and water seems to be essentially necessary to enable bodies to assume the aerial form.

Fixed air has no action upon siliceous earth.

The three alkalis form concrete crystallizable salts when united with fixed air, which being in fact neutral salts, are much less active than the caustic or pure alkalis themselves. These salts still continue to be called the mild alkalis, because the fixed air, though it forms a large proportion of their weight, is displaced by most other acids, and therefore does not obviously seem to impair their alkaline properties: besides which, as this volatile acid flies off in the elastic form, and is lost in common experiments (exhibiting no other indication of its presence than the violent ebullition which accompanies its escape), it was formerly overlooked, and even at the present time is not always sufficiently attended to.

Alkaline air and fixed air unite, and form the concrete volatile alkali.

The combination of fixed air with inflammable substances has not been accurately examined. Metallic calces usually contain more or less of this acid. Plumbago or black lead is the most remarkable compound into which it enters. This affords much fixed air; but chemists are not agreed with respect to its combustible part, some considering it as the mere principle of inflammability, and others asserting it to be iron. See PLUMBAGO, and also IRON.

AIR, HEPATIC. The foetid vapor which is emitted by sulphureous compounds has long since given rise to various conjectures among the writers on chemical subjects; but it was not properly attended to until the great Scheele examined its properties in the permanently elastic form. This excellent chemist combined sulphur by fusion with quicklime, with manganese, and with fixed alkali. It appears from the facts that water was present in these operations. The air which was collected is the peculiar fluid since distinguished by the name of hepatic air. He also found that sulphur distilled with charcoal afforded the same elastic fluid; that sulphur heated alone in a retort with common air occasioned no change in its dimensions, though its purity was diminished. The change of dimensions must have been too small to be perceived by the method at that time used by Scheele. When the same experiment was repeated with inflammable air, the fluid acquired the smell of hepatic air, but differed from that fluid in not being soluble in water. This acute observer ascertained most of the general properties of hepatic air, and concluded that it is a compound of sulphur and phlogiston with the matter of heat.

Bergman*, Senebier†, Gengembre‡, and Kirwan§, have since made this fluid an object of successful research. Its general properties have been since compared and elucidated according to the French or antiphlogistic theory by M. Fourcroy||, who entirely adopts the ideas of M. Gengembre, and considers it as a compound of sulphur and inflammable air.

To obtain hepatic air, liver of sulphur made by fusion of sulphur with an alkali is

* On the artificial preparation of medicated waters, *Essays*, vol. i. † *Recherches sur l'Air Inflammable*. ‡ *Scavans Etrangers*, vol. x. § *Phil. Trans.* 1785. || *Acad. Par.* for 1786.

placed in a body or glass vessel provided with a recurved tube, and an acid is poured upon it. The hepatic air is then disengaged with a considerable effervescence, and may be collected either over water or mercury. If water be used, it is necessary that it should be heated to 80 or 90 degrees, at which temperature it dissolves very little; and from the experiments of M. Senebier it seems that hepatic air is partly decomposed by mercury, and therefore ought not to be received over that fluid. It must not however be disguised, that the valuable course of experiments of Mr. Kirwan, referred to in the preceding paragraph, were all made over mercury, without any inconvenience or apprehension, though that philosopher had the experiments of M. Senebier before him, and quotes this very fact as a reason why the experiments of the Genevan chemist are not to be depended on. It was the opinion of Bergman that the hepatic air exists ready formed in the hepar; but from the experiments of M. Gengembre and Kirwan, it is ascertained that the hepar does not afford it by heat unless water be present: inasmuch that after the common air of the retort, and the fixed air which may be contained in the alkali, have passed over, there is no more air afforded, and the sulphur sublimes alone when the temperature is raised to ignition. But as the former has observed, the addition of a small quantity of water enables it to give out a great quantity of hepatic air by distillation. Hence it follows, either that the water afforded one of the principles of the hepatic air, or that the presence of this fluid is necessary to the aeriform state. Another experiment seems to shew this in a more decisive light. If marine acid air be added to very dry liver of sulphur in powder, it turns it white; the sulphur is separated without any apparent commotion, and very little hepatic air is produced. The small quantity of water in the acid air seems to be the cause of this last circumstance; and though it may indeed be urged, with considerable probability, that the water already existing in the acid air ought to have been sufficient to have produced the hepatic air according to either theory, yet it must be admitted that the neutral salt produced by the combination of the acid and alkali might have absorbed the whole. This experiment, if repeated with the addition of a small quantity of water, is attended with effervescence and the disengagement of hepatic gas.

M. Gengembre is of opinion that the effect of water in the production of hepatic gas arises from its decomposition. For though, according to the various experiments in which water is supposed to suffer decomposition, it has not been shewn that the alkali, nor indeed the sulphur, can separate its principles, yet it is urged that, in conformity to many other examples in chemistry, the attraction of the sulphur for vital air, by which it is converted into vitriolic acid, is greatly forwarded by the attraction which the alkali has to that acid, and by virtue of which it therefore assists the combination. In this way then, according to the antiphlogistians, it is that the vital air of water is disposed of to convert one part of the sulphur into vitriolic acid, while the other principle, namely inflammable air, is taken to combine with another portion of the sulphur, and form hepatic air.

When iron and sulphur are mixed together with a little water, they afford a large quantity of hepatic air by distillation, and the residue contains the salt of iron united to vitriolic acid; and so likewise, when the alkaline hepar is distilled with water, this air is emitted, and the residue contains the neutral salt formed by the combination of alkali with vitriolic acid. In these and similar experiments the maintainers of the ancient theory must say that part of the sulphur is converted into vitriolic acid by the loss of its phlogiston, and that, according to Scheele's inference, the disengaged phlogiston uniting with another portion of the sulphur, together with the matter of heat, forms the hepatic air; and the absolute necessity of water to the aeriform state will

account

account for the experiments not succeeding without that fluid. It must be confessed, however, that in the solution of these facts the antiphlogistic theory seems to possess the advantage, if the compounded nature of water be admitted; and even in that leading dispute it affords no small probability that water really contains vital air: for numerous facts shew that vitriolic acid contains vital air, and we know of none which shew that either sulphur, or iron, or alkali contain it. But as the sulphur becomes vitriolic acid, it must have derived vital air from some of the principles, and the water is the only one suspected of containing it. In this way, the decomposition of water and the volatilization of sulphur in combination with inflammable air, may be applied to account for the various hepatic exhalations emitted from such animal and vegetable substances as are known to contain sulphur.

In Mr. Kirwan's excellent series of experiments on hepatic air received over mercury, we find that the marine acid is the best adapted to the production of this air; that nitrous acid affords nitrous air also unless it be greatly diluted; that concentrated vitriolic acid indeed decomposes the liver of sulphur, but with the extrication of little air, unless assisted by heat; that when the proportion of sulphur in the hepatic much exceeds that of the alkali, the strong vitriolic acid poured upon it emits vitriolic acid very much loaded with sulphur, which it deposits in the course of a few hours with the loss of at least five sixths of its former dimensions. He found that oil of olives, charcoal, and also sugar, afforded hepatic air by distillation with sulphur, the latter of which had the smell of onions; but that plumbago afforded none.

The same chemist, in his endeavours to combine sulphur with elastic fluids, obtained the following results. Sulphur heated in a retort with inflammable air acquired an hepatic smell, but afforded no hepatic air. Liver of sulphur exposed to fixed air for five days, at the temperature of 70° , became somewhat whitened on the surface, and the air had not an hepatic smell, but rather that of bread. The fixed air seems to have received a small accession of sulphur or of hepatic air. Little effect was produced by exposing sulphur to marine acid air in a common temperature.

M. Hassenfratz * attempted to discover the nature of sulphureous airs by synthesis. For this purpose he passed fixed air through sulphur in fusion, and the product was a sulphureous fixed air which precipitated lime-water, and parted at the same time with its sulphur, which was either left on the surface of the water, or sent in a cloud to the bottom together with the calcareous earth. Nitrous air by the same treatment dissolved some sulphur, which it let fall when it was mixed with vital air. Phlogisticated air also took up a portion of sulphur which separated by standing over water. Vital air converted part of the sulphur into volatile vitriolic acid, or vitriolic acid air, which was absorbed; and another portion of the vital air sustained a part of the sulphur undecomposed, which fell down when the vital air was united with nitrous air, or detonated with inflammable air. Atmospheric air produced an effect correspondent to that of a mixture of vital and phlogisticated air. And lastly, inflammable air, passed through sulphur in fusion, produced hepatic air.

Mr. Kirwan has observed however, that no one has yet decomposed hepatic air, so as to leave the inflammable air behind. The general character of his hepatic air received over mercury were the following: Its specific gravity was greater than that of common air in the ratio of 11 to 10, when the barometer stood at 29.94 inches, and the thermometer at $67\frac{1}{2}^{\circ}$. It is inflammable, but never detonates with common

* Phil. Trans. lxxvii. p. 305.

air, and a very considerable proportion of this last fluid is required to enable it to be fired in a narrow-mouthed vessel. M. Senebier did not find that his air received over water could be fired by the electric spark, though mixed with any proportion of respirable air. When hepatic air is burned there is a continual deposition of sulphur. Nitrous air enables hepatic air to burn partially; but equal proportions of vital and hepatic air explode with great violence.

Every species of hepatic air indicates a slight acidity by turning the tincture of litmus red, even though it has been washed in water, or previously dissolved in and expelled from that fluid. With respect to solubility in water, the hepatic airs extracted from different materials vary considerably. In the temperature of 66° Mr. Kirwan found that water by slight agitation dissolves two thirds of its bulk of alkaline or calcareous hepatic air extracted by marine acid; eight tenths of that extracted by means of the concentrated vitriolic, or the dilute nitrous or saccharine acids, at the temperature of 60° ; seven tenths of that obtained by the acid of borax; nine tenths when acetous acid is used, or when sulphur is boiled with oil of olives; and its own bulk of that produced by heating a mixture of sugar and sulphur. In general Mr. Kirwan imagined that which required the most heat for its production to be the most soluble; though in some instances, particularly that of acetous hepatic air, he observes that this circumstance did not take place. The most remarkable phenomenon respecting the solution of hepatic air in water is, that though it is not expelled by water at a less heat than that of ebullition, yet it is spontaneously separated in a few days, for the most part in the form of sulphur, which falls down, and this though the bottle be ever so well stopp'd.

The action of hepatic and other aerial fluids on each other was also ascertained by this chemist. Equal parts of common and hepatic air standing over mercury for eight days did not suffer any change, though the surface of the mercury was slightly blackened. The same experiment was repeated with vital air, phlogisticated air, inflammable air, marine acid air, and fixed air, without any change denoting mutual action. Vitriolic acid air produced a deposition of sulphur, and a very great diminution; inasmuch that six measures of hepatic air added at intervals to five of vitriolic air, left a residue of three measures only. This residue was not affected by nitrous air; extinguished flame; and one measure of water agitated with two measures of this residue, absorbed four tenths of its bulk, and left phlogisticated air behind. The water appeared to have taken up a minute portion of vitriolic acid. When the precipitated sulphur was washed with water, this fluid was found to contain some fixed air and a considerable portion of vitriolic acid.

Nitrous air in its usual state, in the proportion of nine measures to eight of the hepatic air, afforded a yellowish cloud of sulphur with a diminution of about two measures, which in the course of forty-eight hours increased so much, that the residue was no more than six measures. The top and sides of the jar were then covered with a cake of sulphur, and the aerial residue was the fluid called dephlogisticated nitrous air, in which a candle burns naturally.

When nitrous air was deprived of its adventitious acid by mixture with alkaline air, and washing with distilled water, it appeared to lose about one sixth of its bulk. Hepatic air, in the proportion of 7 to 8, being admitted to this nitrous air, produced no immediate effect; but in six hours, under the temperature of 72° , the whole was reduced to 5 parts or cubic inches, and a much whiter sulphur was deposited than in the preceding experiment. This air flashed with so much violence as to extinguish a candle dipped into it. The flame was exceedingly white and vivid, and from its

other properties this air seemed to be in the most perfect stage of that state which Dr. Priestley calls dephlogisticated, and in which it certainly appears to be highly disposed to part with its vital air in a red heat. See ACID, NITROUS, page 31.

Alkaline and hepatic airs nearly destroy each other. Mr. Kirwan mixed equal parts of hepatic air from liver of sulphur and of alkaline air. A white cloud was produced, which left a whitish scum on the sides of the jar, and the mixture was reduced to one twelfth part of its original bulk. Of this residue half was absorbed by water, and the remainder seemed to be common air of the vessels. Seven measures of very pure alkaline air being added to six of calcareous hepatic air, a white cloud and a little white scum at first appeared; but in a few seconds the whole was reduced to six sevenths of a measure, which was all absorbed by the addition of two measures of water, except one ninth of a measure, and this residue extinguished a candle. The scum appears to be almost liquid, and as soon as the jar is emptied of mercury, it breaks out into a white smoke with an exceedingly sharp urinous smell. In his experiments, by adding alkaline air to the hepatic airs obtained from sulphur and iron, and also from sulphur and sugar, the diminution was nearly as considerable, though very slow in the last case, and the small residues unabsorbed by water were inflammable air.

Mr. Kirwan also examined the mutual action of hepatic air, and acid, alkaline, and inflammable liquors. One measure of concentrated vitriolic acid absorbed two measures of hepatic air, except one tenth of a measure, and became whitened by a copious deposition of sulphur. It was difficult to mix it with nitrous acid without diluting it so as not to act upon mercury; but when the acid was so far diluted, it absorbed eight tenths of its bulk of hepatic air, passed through the mercury, and the residuum detonated when the hepatic air from iron and sulphur was used; but when the alkaline hepatic air was used, the residuum did not detonate, but burned with a blue and greenish flame, and sulphur was deposited on the sides of the jar. Two measures of alkaline hepatic air being exposed to one of strong marine acid, were absorbed by slight agitation all but one fifth of a measure. A third of a measure being added, there remained, after some agitation, but half a measure. Sulphur was precipitated as usual; but the mercury over which the acid stood attracted it from the acid, for it was blackened, which did not happen when the former acids were used. The residuum burned just as pure hepatic air. Distilled vinegar absorbs nearly its own bulk of air, and becomes slightly whitened; but by agitation it may be made to take up about twice its bulk, and then becomes very turbid.

One measure of caustic vegetable alkali, of the specific gravity of 1.043, absorbed nearly four measures of alkaline hepatic air, which rendered it at first brown, though it afterwards became clear by the deposition of sulphur upon the face of the mercury. Caustic volatile alkali, of the specific gravity of 0.9387, absorbed 18 times its bulk of hepatic air; and Mr. Kirwan, from the circumstance that the greater the quantity of alkali the greater the absorption, thinks this the best method of determining the strength or real contents of such alkaline liquors. The smoking liquor of Boyle is prepared with great facility by impregnating caustic volatile alkali with hepatic air.

Mr. Kirwan proceeds in his paper to relate his experiments on the combinations of hepatic air with oil of olives, new milk, oil of turpentine, spirit of wine, and ether. He ascertains more minutely the properties of water, and also of alkaline liquors impregnated with alkaline air; and then treats of the theory of this elastic fluid, in which he avails himself of the modern doctrine of heat with peculiar felicity.

He finds it difficult to conclude that hepatic air consists of any thing else than sulphur

fulphur itself kept in an aerial state by the matter of heat; and in particular he takes notice that every attempt to extract inflammable air from hepatic air, when drawn from materials that previously contained nothing inflammable, proved abortive; though, on the contrary, when it was procured from such materials as could supply inflammable air, the smallest proportion of that fluid was detected. He shews that it cannot consist of liver of sulphur volatilized; because it may be extracted from materials, such as iron, sugar, oil, and charcoal, which either contain no alkali, or a quantity altogether inconsiderable; and because it is not decomposable by marine or fixed air, which nevertheless decompose the liver of sulphur. Neither can he admit of the supposition that the sulphur in this air is sustained in solution by the marine or vitriolic airs, because it is producible from materials which contain neither of these acids; and from whatever subject it is obtained, it exhibits the characters of one and the same acid, namely, the vitriolic exceedingly weakened: and such an acid, he observes, we may suppose sulphur itself to be; for sulphur unites with alkalis, calcareous and ponderous earths, and most metals, as a weak acid might; and, except a manifest solubility in water (a property likewise possessed in a very weak degree by some other concrete acids), it exhibits every character of acidity.

After thus rejecting the principal positions respecting the other compound matter which unites with sulphur in the composition of hepatic air, our author continues to state that Scheele has ascertained that the matter of heat enters into its composition. This chemist found that acids excited much less heat in uniting with liver of sulphur, whether alkaline or calcareous, than while uniting with a proportion of caustic fixed alkali or lime equal to that which enters into the composition of those livers; whence he justly infers that the difference enters into the composition of the hepatic air produced. Mr. Kirwan, to prove the same thing, added marine selenite and marine Epsom to solutions of liver of sulphur, and found that the *hepar* was really decomposed, though no hepatic air was afforded: for the acid, he observes, having given out its specific heat in uniting with the earths, had none to lose or communicate on uniting with the alkali, and consequently the sulphur receiving none, could not be thrown into the aerial state.

It is remarkable, continues he, that bodies capable of an aerial form receive the latent heat necessary for that form much more readily from a body that parts with its specific heat than by the mere application of sensible heat. Thus aerated barytes, or the native combination of ponderous earth with fixed air, cannot be decomposed by mere heat, though its air is easily separated from it by an acid; and in the same manner antimony cannot be cleared of sulphur even by vitrification, though it may by acids: so liver of sulphur will not give hepatic air by mere heat, though it will by the intervention of an acid, even the weakest. And the reason he states to be this: The matter of heat has no particular affinity with any substance, as is evident from its passing indifferently from any hot body to a colder, of whatever sort or kind the bodies may be; but it is determined to unite with this or that body in a latent state, in greater or less quantity, in proportion to the greater or less capacity of those bodies to receive it. Now acids, by uniting to the alkaline basis of the liver of sulphur, expel the sulphur, and give it their heat at the instant the sulphur by its separation has the capacity to receive it: whereas sensible external heat, acting alike on both the constituent parts of liver of sulphur, separates neither; or if it separate them, yet by its successive action it throws one of them into a vaporous state first; and bodies that first acquire this state can never after, he affirms, acquire an aerial state by any subsequent accession of heat.

He thinks that the vitriolic and nitrous acids are less adapted than the marine to

the production of hepatic air, most probably because they have a stronger attraction to the sulphur, and so detain it.

He accounts for the condensation of hepatic air in water, from its great aptitude to give out its latent heat, particularly when in contact with substances to which it has any affinity. The precipitation of metals he ascribes partly to its phlogificated acids, and partly to its union with the metals themselves.

The union and condensation of hepatic and alkaline airs are readily accounted for by him, from the known affinity or elective attraction of these substances to each other : and for the contrary reason it is as easily understood why common dephlogificated, inflammable, and phlogificated airs have so little action upon it. The strong action of vitriolic air is considered by him as pretty evidently arising from attraction, as is likewise the condensation of nitrous air : but these circumstances certainly require to be further investigated in any theory.

On the whole therefore we may observe, that the theory of the composition of hepatic air from a combination of inflammable air and sulphur being proved by no direct experiment but that concisely related by Hassenfratz in the Philosophical Transactions, and inferred in other instances from the disputed doctrine of the decomposition of water, labours under several difficulties. This decomposition is doubtful; the theory does not account for such decomposition taking place in the common instance where sulphur is separated from the hear by an acid, and most of the facts it insists upon may be as well explained upon Mr. Kirwan's theory. But, on the other hand, Mr. Kirwan's theory, though it opens an extensive field of research highly worthy of the utmost attention of chemists, labours under difficulties perhaps of equal magnitude. The materiality of heat is a contested point; and though the general facts may be treated of without necessarily requiring a decision of this great question, yet there are so few yet investigated, that the transitions of heat in particular instances do not stand much higher, for want of experimental proof, than any other ingenious hypothesis, which, though it may be true, does not command our whole assent till farther proofs are exhibited. If the heat excited by chemical mixtures be supposed to depend on peculiar motions, the inferences respecting the changes of temperature in chemical operations will take a different form; and in decompositions, where four principles are concerned, the defect of elastic matter may be ascribed to the effect of double affinities by those who are disposed to reject the doctrine of the transition of a matter of heat : and lastly, though liver of sulphur emits no hepatic air by mere heat, though it will by the intervention of an acid, and this is stated to depend on the acid giving out its latent heat when it enters into combination with the alkali; yet the same doctrine seems insufficient to account for the production of hepatic air from liver of sulphur when heated with mere water, unless the water be supposed also to have given out its heat in combining with the alkali. In this case we ought therefore to find water, alkali, and sulphur; whereas in fact we find alkali and vitriolic acid: so that the water must either have dephlogificated the sulphur, or afforded vital air, and by that means have converted it into vitriolic acid.

From these observations it appears that several experiments require to be made, and carefully repeated, before we can with certainty consider ourselves in possession of a complete theory of hepatic air. And these researches are so much the more desirable, as they nearly relate to the great questions of the composition of water and the constitution of acids.

AIR, INFLAMMABLE. All animal or vegetable substances which can be burned by heating in the open air, will afford inflammable air if heated in closed vessels.

vessels. It appears however to be a general rule or condition, that water should be present in every case wherein inflammable air is produced, whether it be that this elastic fluid is most frequently afforded by the decomposition of water, or whether it be indispensably requisite that water should be present, and form part of every permanently elastic fluid. The inflammable air of animal or vegetable bodies is usually mixed with air of other kinds, and with oleaginous or other immediate principles that are volatilized, and commonly remain suspended for an unlimited time. Some of the metallic substances, during their solution in acids, or when ignited in contact with water or steam, emit or extricate inflammable air, which is considered to be the purest of any.

Chemists are not agreed whether inflammable air in all its varieties do consist of one and the same matter vitiated by the admixture or solution of other substances, or whether these several kinds differ essentially from each other. Mr. Kirwan considers it as phlogiston nearly pure, and consequently infers that it escapes or is disengaged in the combustion or calcination of metals, as it certainly does in all the ordinary instances of combustion. The philosophers who hold this opinion must therefore most eminently maintain that pure inflammable air is one and the same substance, and that all combustible bodies whatever consist of this identical matter combined with other bases, by which its apparent properties are varied. The chemists of the antiphlogistic school, though they do not admit of any general principle or cause of combustibility, except a strong attraction for vital air, are nevertheless of opinion that pure inflammable air is one of the simplest bodies in nature, capable of dissolving and suspending a great variety of bodies, and that all the inflammable fluids yet discovered are nothing more than inflammable air holding other bodies in solution. They have accordingly availed themselves of this position, together with the decomposition of water, to account in a very elegant manner for many of the phenomena of nature and art. See HEPATIC AIR; VEGETABLE KINGDOM; WATER.

The process for obtaining inflammable air in its purest state consists in dissolving metallic bodies in acids, and collecting the elastic fluid which escapes during the effervescence that takes place. These operations are treated of under the respective metals. That most commonly used consists in dissolving iron shavings or wire in diluted vitriolic acid. The specific gravity of this inflammable air is usually about one tenth of the common air of the atmosphere, but it is said to have been obtained seventeen times lighter. Of this however I very much doubt. From this extreme rarity it has been applied to float air-balloons, the instances of which are too numerous, and have too strongly claimed the public attention, to be recited in this place. Inflammable air, like every other permanently elastic fluid which does not contain vital air, is incapable of maintaining combustion, or of taking fire by the electric spark, though it be itself eminently inflammable when vital air is present.

It is remarkable that all the acids which are capable of affording air by the solution of metals give inflammable air when the solution is properly conducted for that purpose, the nitrous acid excepted. But this acid, whether it be concentrated or diluted, affords only nitrous air more or less modified. From this and other circumstances, the antiphlogistic philosophers have inferred that the inflammable air which appears during the solution of metals is in all cases produced by the decomposition of the water with which the acid is diluted, and that the acid answers no other purpose in these operations than to facilitate the decomposition by virtue of its attraction for the metallic calx: that is to say, according to this theory, of which Mr. de la Place is the author, the metal considered as a simple substance attracts vital air from the water, but not with sufficient force to decompose that fluid, if it were not for the

the acid which tends to dissolve this compound or metallic calx, and by that means facilitates the decomposition of the water. The other principle of the decomposed water, namely the inflammable air, flies off. *See METALS.*

The same question concerning the decomposition of water, and the existence of phlogiston or inflammable air in metals, continually presents itself in accounting for the calcination and reduction of those bodies by either of the two theories of chemistry. A large quantity of inflammable air is afforded when the steam of water is caused to pass through a red hot iron tube, and indeed the same effect takes place when iron is immersed for a length of time in pure water, though the quantity of inflammable air is not considerable. The iron itself is converted into that kind of calx which is known at the forges by the name of finery cinder. If this calx be heated with the burning glass in inflammable air, its metallic state is restored, and water appears. Here also the antiphlogistians conclude that the water is decomposed, and again recomposed, during the revival of the iron. But the phlogistian philosophers consider the inflammable air as consisting chiefly of phlogiston, which they state to be one of the component parts of the iron; and consequently they infer that finery cinder consists of water united to the calx of iron, or iron deprived of its phlogiston; and in the process of revivification they affirm, that the inflammable air or its phlogiston has combined with the calx of iron, and expelled the water which accordingly appears.

We have had frequent occasion to state the composition of water as being formed of vital and inflammable air in due proportions united at a red heat; and under the article WATER we have stated the experiments and inductions upon which this position depends. We shall therefore only remark in this place, that the combustion of vital and inflammable air affords water in very considerable quantities, together with nitrous acid and fixed air; and that the antiphlogistians consider water as compounded of the two first, while they suppose the latter to be impurities arising from the presence of phlogisticated air and charcoal (*see ACID, NITROUS; and AIR, FIXED*): but that, on the other hand, Dr. Priestley, and several of the chemists who believe in the existence of phlogiston, think that the two airs produce nitrous acid and fixed air, according to the state of the combustion, and that the water which appears is nothing else but that which pre-existed in the airs, and is essential to their state of elastic fluidity.

The electric spark taken in any kind of oil produces inflammable air, and the same is the case with ether, except that this last is absorbable by water, all but one third, which residue is the inflammable part. It is probable that the absorbed part is vitriolic acid air. Spirit of wine likewise affords inflammable air by the same process. Dr. Priestley observes, that the electric spark probably afforded the heat which is necessary to give the permanently elastic state to the inflammable part and the water contained in these fluids.

In the extrication of inflammable air by heat from combustible substances the management must be different according to their respective natures. If the substances be fluid, heat applied to them directly makes no change in their constitution, except by volatilizing some of their principles, and decomposing the solid residues. But when fluids are made to pass in the form of vapour through tubes previously made red hot, in which they are necessarily exposed to a red heat themselves, they are readily decomposed. Two ounces of spirit of wine by this treatment afforded about 1900 ounces of inflammable air, which burned with a white flame, and had no mixture of fixed air, which from experiment was found to weigh about 633 grains, and the watery residuum was 168 grains: so that there were 20 grains either lost in the operation,

or

or not accounted for in the estimate or inferred state of the weight of the aerial product. Vitriolic ether also afforded much inflammable air without any fixed, as did also spirit of turpentine and olive oil mixed with whiting. From other experiments it is clearly ascertained that flame consists of inflammable air extricated from combustible bodies by heat, and taking fire by virtue of that heat and the access of atmospheric air.

Sulphur inclosed in an earthen tube, and melted, affords inflammable air when steam is passed over it. This is of the same quality as is procured from iron by vitriolic acid; and consequently affords the same field for discussion respecting the decomposition of the water, or the phlogiston of the sulphur, as presented itself in that case.

Inflammable air absorbed by hot charcoal, and again expelled by immersion in water, does not appear to have undergone any remarkable change in its properties: neither is it rendered less inflammable by the putrefaction of animal or vegetable substances in it. Plants also grow in this fluid, without impairing its inflammability. Water imbibes about one thirteenth of its bulk of this air, which being afterwards expelled by heat proved as inflammable as ever. Dr. Priestley found however that it became converted into respirable air by agitation in water: doubtless by the gradual admixture with the external air; for Hassenfratz* appears to have clearly decided that water kept in contact with inflammable air for three years makes no alteration in the properties of that aerial fluid.

The electric spark taken in inflammable air has a red colour, but does not produce any other change in it but the deposition of a small quantity of acid†, which is probably extraneous to it. Change of temperature only changes its dimensions for the time, when it has free liberty to expand: but when this fluid is exposed to a red heat in a flint glass tube hermetically sealed, it renders its surface perfectly black, most probably by reviving part of the calx of lead which enters into the composition of that body. This is rendered nearly certain by heating minium in the black tube, which immediately restores its transparency, no doubt by virtue of the pure air which it is known to emit by heat, and which again calcines the lead in the glass, while the minium itself approaches towards the metallic state.

The revival of metals by heating them with a burning glass in inflammable air over mercury affords matter for speculation of the most interesting nature, and is explained according to both the theories of chemistry. The general facts are, that the calces of lead, iron, mercury, and other metals, are reduced more or less to the metallic state by such treatment, while part of the inflammable air disappears, and water is produced, the metals being, as in other cases, of less absolute weight than the calces from which they were obtained. It must be confessed that these experiments being upon so small a scale, afford room for controversy respecting the quantity and even the nature of the products; but taking the results as here stated, the inferences according to the several theories will be, first, according to the phlogistic theory it must be concluded that the inflammable air supplies phlogiston to the metal and reduces it, and that the water has been either emitted by the calx, or deposited by the inflammable air, the former of which is rendered probable from the power of calcining many of them by mere heating in contact with steam, and the latter from a variety of facts; or, according to the modern theory, the inflammable air unites with the vital air of the calx, and forms water, while the metal becomes reduced simply by the loss of the air which calcined it. This is somewhat simpler; because, according to the

* *Annales de Chimie*, I. 173.

† *Description de la Machine Electrique de Teyler*, I. 122.

other explanation, there must be two ways of calcining metals, one by combining them with water, and the other with vital air; a circumstance which however is very far from being improbable.

Charcoal, which by heat, in contact with vital air, affords fixed air (see page 84), produces fixed air, together with an heavy kind of inflammable air, when steam is passed over it in a state of ignition. This is concluded by Dr. Priestley, and many other chemists, to be an intimate combination of fixed air and inflammable air; as indeed seems to be sufficiently proved by burning it with vital air, in which case a very considerable residue of fixed air is left. In some cases, however, the quantity of fixed air thus obtained exceeds the whole weight of the inflammable air made use of; a circumstance from which Dr. Priestley infers, that the fixed air is produced by a combination of the vital air with part of the inflammable air. But the French chemists, who consider fixed air as an acid composed of vital air, united with a peculiar basis which forms the greatest part of the weight of charcoal, find no difficulty in accounting for this surplus of weight in the fixed air afforded or left after burning the heavy inflammable air: for they state, that this last aerial fluid consists of light inflammable air holding charcoal as the base of fixed air in solution; and they easily admit that this basis may require more vital air to acidify it, than it before required of inflammable air to dissolve it; in which case the fixed air will really be the heaviest; not to mention that this fixed air may suspend a larger quantity of water than the dense inflammable air was capable of supporting.

The inflammable air of marshes, which is emitted from the waters of standing pools, drains, or privies, is the same as is produced by the putrefaction of organized substances, especially animal matters, in water. It is emitted either before or after the production of the volatile alkali which is afforded by this last stage of spontaneous decomposition. When it is consumed by detonation with vital air, it leaves a residue of phlogisticated air, and appears to differ from volatile alkali in the proportion of its principles and their want of combination, and also probably in the admixture of sulphur or phosphorus in some cases, which may render it hepatic. It would not be difficult to exhibit situations in which inflammable air and phlogisticated air might be emitted from putrefying substances without combining together, either in consequence of their rapid acquisition of the elastic state, in which, either by the interposition of the matter of heat in a latent state, or more probably by the particles being thrown beyond the usual limits of chemical attraction, they would be kept apart: but this subject demands to be farther prosecuted by experimental research. *See* WATER; IRON; PHLOGISTON.

AIR, MARINE, *or* MARINE ACID AIR. The marine acid readily assumes the permanently elastic state by the application of heat, or by expelling it from combinations in which the disengaged acid does not meet with a sufficient quantity of water to hold it in solution. For the general properties of this aeriform acid, *see* ACID, MARINE.

AIR, MARINE, AERATED, *or* DEPHLOGISTICATED. *See* ACID, MARINE, AERATED, *or* DEPHLOGISTICATED.

AIR, NITROUS. This air is a modification of the nitrous acid from which part of its vital air has been separated, at the same time that, according to the followers of Stahl, it has received phlogiston or the principle of inflammability. *See* ACID, NITROUS.

AIR, NITROUS, DEPHLOGISTICATED. The nitrous acid upon its decomposition or phlogification is deprived of vital air, and receives phlogiston according to the ancient theory. During this progress of change it becomes red nitrous acid, nitrous air, dephlogisticated nitrous air, and lastly, phlogisticated air.

The

The dephlogisticated nitrous air, which is remarkable for its want of acidity, like the air called nitrous air, and its resemblance to vital air in maintaining combustion, though like phlogisticated air it is fatal to animal life, is produced only in certain circumstances. Its constitution has not yet been clearly investigated; and chemists have either supposed it to possess more vital air, and less phlogiston, than nitrous air, or the contrary, accordingly as their attention was fixed upon one or other of its several properties. To me it seems to be a triple compound of vital air, phlogisticated air, and inflammable air; and that the extrication of the former principle is facilitated, in certain circumstances, by the disposition of the two latter to combine, and form volatile alkali. But experiments are wanting to decide on this subject. *See ACID, NITROUS.*

AIR, PHLOGISTICATED. The residue of common air vitiated by combustion, or any other process by which phlogiston is supposed to be extricated, is most commonly known by the name of phlogisticated air. The French call it azote; and some chemists distinguish it by the name of mephitic, or mephitic gas; none of which terms indeed denote any property exclusively possessed by this elastic fluid, though preferable to the former denomination, which refers to a supposition neither proved nor generally admitted. It is not however our business to change the names which are generally found in the writings of the best chemists; and for this reason we treat of it by the former appellation.

The characteristic properties of the several permanently elastic fluids are in general very easy to be exhibited. Thus vital air maintains combustion, and acidifies nitrous air; fixed air is absorbed by lime-water, and precipitates the lime in a mild state; alkaline air forms a white cloud with acids, besides exhibiting its own peculiar smell; nitrous air speedily forms nitrous acid by combining with vital air. And the other airs have also their respective criterions, which may be seen by consulting the several articles. Phlogisticated air however seems, in general, to have been distinguished in no other way than by its not possessing any of the distinctive marks of the other known airs: so that, in all operations, the aerial residues which exhibited neither acid nor alkaline properties, nor were absorbed by water, nor affected other kinds of air by combining with them and altering their dimensions, have been called phlogisticated air. The positive properties best calculated to distinguish this kind of air from every other, are, its forming nitrous acid by mixture with vital air, and electrization; and its forming volatile alkali by combination with inflammable air. The first of these operations is very long, and the latter, though continually performed by nature, cannot be done with any degree of facility in the operations of art; because the elastic state of the two fluids prevents their combination. *See ACID, NITROUS, page 33; and also AIR, ALKALINE, page 75—78.*

Among the great number of processes by which the air of the atmosphere may be rendered noxious, or deprived of its respirable part, it is evident that some of them will be better calculated than others to afford the residue of phlogisticated air unmixed with other elastic fluids. The combustion of phosphorus affording an acid not at all volatile is one of the best methods, but by no means among the cheapest. When common air is exposed to liver of sulphur, or to iron filings and sulphur moistened, it becomes completely divested of vital or dephlogisticated air; but in the first case the emission of hepatic air causes an impurity in the residue, and in the latter there is not only an emission of inflammable air, but likewise a formation of volatile alkali by the combination of the inflammable air in the nascent state with part of the phlogisticated air. The air bladder of the carp contains phlogisticated air of considerable purity; but this can be obtained only at certain seasons when the fish are in
O plenty.

plenty. The purest phlogisticated air is said to be that which is obtained by causing the dephlogisticated or aerated marine acid, as it is disengaged in the aerial form, to be received in a bottle containing the most pure volatile alkali. In this case the volatile alkali is decomposed; its inflammable air combines with the vital air of the marine acid, while its phlogisticated air is emitted.

The excellent Berthollet, in his enquiries into the nature of animal substances, found that phlogisticated air, or its base, composes a large proportion of their masses. He draws this inference from the consideration, that it is disengaged in large quantities by the application of a weak nitrous acid at a moderate temperature (see page 40). M. de Fourcroy * has repeated, and extended these experiments, and finds,

1. That azote (phlogisticated air), or its basis, is so abundant in animal matters, that the weakest nitrous acid, assisted by a slight elevation of temperature, is sufficient to disengage it. The heat of the atmosphere, when it exceeds seventy degrees, is sufficient for the purpose. But when a greater heat is applied by art, the disengagement is interrupted by an absorption, which requires the experiment to be made with caution.

2. The quantity of phlogisticated air is not the same from different animal parts. Gelatinous substances afford the least; next to these the aluminous matter which hardens and becomes opaque by heat, such as the white of egg. Serum of blood, cheese, and the like, afford a larger quantity. And most of all the concrescible fibrous matter, such as the clot of the blood, and the greater part of the muscles, affords the largest quantity of phlogisticated air.

3. The flesh of young animals affords less than that of old. But the difference is not considerable between frugivorous and carnivorous animals, or between fishes and quadrupeds, except that the latter appear to afford it more readily; a circumstance from which this chemist supposes the greater promptitude of fishes to putrefy may arise.

4. The nitrous acid requires as much alkali to saturate it after it has served this process as before. If the product of true nitre were equal in both cases, this circumstance would incontrovertibly prove, that the phlogisticated air came from the animal substance, and not from the nitre: but in the saturation of nitrous acid the quantity of alkali will differ accordingly as the acid itself is more or less fuming or phlogisticated.

5. The proportion of phlogisticated air afforded by various animal substances in this way is in proportion to the volatile alkali they respectively afford by distillation; and such bodies as, by spontaneous change or putrefaction, have become in part converted into volatile alkali, do not afford any phlogisticated air.

Phlogisticated air is less heavy than common air. It suddenly extinguishes flame, and very quickly and inevitably destroys animal life. If it be mixed with vital air in the proportion of about 72 parts to 28 of the vital air, it forms a fluid not perceptibly differing from the air of the atmosphere. No evident effect takes place between phlogisticated air and water, or earthy substances. Nitrous acid absorbs a portion of it, and is rendered fuming. Delicate blue colours are slightly reddened by this air. Its smell is peculiar and unpleasant. Agitation in water and the effects of vegetation have been found to render it more respirable than before. But these facts do not appear to be any proof that it contains vital air; for it is well known that any air agitated in a tub of water becomes gradually mixed with the air of the atmosphere; and when plants vegetate in phlogisticated air, and render it less

* Annales de Chimie, I. 40.

noxious, it is most probable that this effect arises from the vital air which plants are known to emit in certain circumstances during life, together with the absorption of part of the phlogificated air which they imbibe.

AIR, PHOSPHORIC. The phosphoric acid resembles dense vitriolic acid, in the difficulty with which it assumes the vaporous form, and the readiness of its subsequent condensation. Dr. Priestley's attempts to obtain it in the aerial form, by treating it with mercury and with ardent spirits, were ineffectual; and though it acted upon iron, yet the aerial produce was inflammable, which the Doctor does not seem to think of a phosphoric nature.

Phosphorus however, which in so many particulars resembles sulphur, is likewise capable of affording a permanently elastic fluid of the hepatic kind, when it is heated with alkali *. Ten or twelve grains of phosphorus were mixed with about half an ounce of caustic fixed alkaline solution in a very small phial, furnished with a bended tube, and the air was received over mercury. Upon the first application of heat, two small explosions took place attended with a yellow flame and white smoke, which penetrated through the mercury into the receiver; these were followed by an equable production of air. At last the phosphorus began to swell and froth; and the rupture of the phial being feared, the tube was stopped to prevent the access of atmospheric air. But while disposition was making to disengage the phial and tube from the apparatus, and throw it into a water tub, it burst with a loud explosion, by reason of some obstruction in the tube, and a fierce flame immediately issued from it. The quantity of air obtained was however about 8 cubic inches.

This air was diminished very slightly by agitation with an equal bulk of water, and then became cloudy like white smoke, but soon afterwards recovered its transparency. Upon turning up the mouth of the tube to examine the water, the unabsorbed air instantly took fire, and burned with a yellow flame without exploding, leaving a reddish deposit on the sides of the tube. The temperature was 68°.

Water impregnated with phosphoric air, and over which this air had burned, slightly reddened tincture of litmus, and did not affect Prussian alkali: but water impregnated with this air, without suffering the air to burn over it, scarcely affected litmus.

To a measure of phosphoric air, Mr. Kirwan let up a measure of water, and through this some small bubbles of common air; every bubble flamed, and produced a white smoke, until about half as much common air was introduced as there was originally of phosphoric; and yet the original bulk did not seem to be increased. The flame each time produced a small commotion, and a smoke descended after inflammation into the water: when flame ceased to be produced, smoke still followed the introduction of more air. Bubbles of phosphoric air, escaping through mercury into the atmosphere, flame, crackle, and smell exactly like the electric spark.

Nitrous air produced a very slight diminution with a white smoke in phosphoric air; alkaline air scarcely at all diminished it; fixed air produced a white smoke, some diminution, and a yellow deposit.

Phosphoric air is speedily destructive of animal life. The difference between this air and sulphureous hepatic air, appears very nearly to follow the greater combustibility and volatility of the phosphorus; and as far as their respective properties are known, their theories are much the same. Some chemists consider phosphoric air as nothing but phosphorus in the aerial state; but most of the antiphlogistian philosophers admit it to consist of a solution of phosphorus in inflammable air, assisted by the decomposition of water.

AIR OF SPARRY FLUOR. See ACID OF FLUOR.

* Kirwan in Phil. Transf. for 1785.

AIR, VITAL, or DEPHLOGISTICATED. This aerial fluid being the grand instrument of combustion, taken in the most extended sense, has so considerable a share in most of the operations of chemistry, that there are few of the articles of the present work which do not tend to explain and elucidate its properties. It composes between one third and one fourth of the weight of the air of the atmosphere, and is absorbed by various bodies, from which it may afterwards be extricated or expelled by heat assisted by the action of light. *See AIR, ATMOSPHERICAL.*

It may be obtained by heat, from mercury calcined without addition; from red precipitate, and other mercurial calces; from minium; from manganese, and other metallic calces; from moist nitrous and vitriolic salts. It is also contained in the bladders of sea weed, and in waters. The green vegetable matter formed in water emits it by the action of light; and it is found in general that the green leaves of plants, exposed to the action of light, emit vital air. Most of the vital air thus obtained is accompanied by an admixture of phlogisticated air. The purest is that from precipitate per se newly made, or preserved in close vessels; or from manganese; or from the leaves of plants.

Vital air is somewhat heavier than the common air of the atmosphere, and maintains combustion longer in proportion to its purity. The combustion by this fluid is astonishingly intense, and appears, when urged by the blow-pipe in a stream upon a small portion of ignited matter, to equal or exceed the powers of the strongest burning lenses or mirrors. We have no account of experiments yet made with both in combination; though there is no doubt but that they would prove highly interesting. The test of nitrous air, and every other fact in which this air is concerned, indicate its superior efficacy or purity, with regard to combustion and the maintenance of animal life. *See ACID, NITROUS.*

Vital air being absorbed or transferred in those combustions in which acids are produced, it is universally admitted as the chief cause of acidity in bodies: that is to say, acids are combustible bodies united with vital air, and deprived of phlogiston, according to the theory of chemistry which admits that principle. *See the general article ACIDS; and also the several ACIDS respectively.*

Most of the heat in combustion is taken to arise from the condensation and change of capacity of vital air, when it passes from the elastic to the dense fluid or solid state. *See COMBUSTION and HEAT.* Heat is, however, produced very frequently by the mere transition of vital air from one combination to another: as, for example, when gun-powder is fired, the vital air of the nitre is transmitted to the charcoal. In such cases the change of capacity may not be always in the vital air, though it seems probable.

Whether vital air in all cases produces an acid by combination in due proportion with combustible matter, has not been yet ascertained. There being no other combustible bodies than metals, acid bases and inflammable air; and several metals being acidifiable; there seems to be little question, except concerning inflammable air. When this is burned with vital air, there is a production of water with nitrous acid and fixed air. Whether the water be formed by the union of vital and inflammable air, and the two acids which accompany it be merely the result of casual impurity; or whether the two airs be employed in forming these acids, while the water is merely deposited, which was before suspended during the permanently elastic state of the airs; are subjects of controversy which at present divide some of the most eminent chemical philosophers. *See WATER.*

Vital air changes the colours of vegetable and animal substances. It is this principle which is the chief agent in bleaching of cloth, and in the hardening of wax. *See BLEACHING.*

AIR,

AIR, VITRIOLIC. When the vitriolic acid is dephlogisticated, or deprived of part of the due proportion of vital air required to constitute the most perfect state of acidity, it becomes volatile, and readily assumes the aerial form. For the various properties and habitudes of the acid in this state, *see* ACID, VITRIOLIC, page 66.

ALABASTER. Among the stones which are known by the name of marble, and have been distinguished by a considerable variety of denominations by statuariers, and others whose attention is more directed to their external characters and appearance than their component parts, alabasters are those which have a greater or less degree of imperfect transparency, a granular texture, are softer, take a duller polish than marble, and are usually of a white colour. Some stones, however, of a veined and coloured appearance, have been considered as alabasters, from their possessing the first mentioned criterion; and some transparent and yellow sparry stones have also received this appellation.

Chemists are at present agreed in applying this name only to such opaque, consistent and semi-transparent stones as are composed of lime united with the vitriolic acid. But the term is much more frequent among masons and statuariers than chemists. Chemists in general confound the alabasters among the selenites, gypsums, or plaster of Paris, more especially when they allude only to the component parts, without having occasion to consider the external appearance, in which only those several compounds differ from each other.

As the semi-opaque appearance and granular texture arises merely from a disturbed or successive crystallization, which would else have formed transparent spars, it is accordingly found that the calcareous stalactites, or drop-stones, formed by the transition of water through the roofs of caverns in a calcareous soil, do not differ in appearance from the alabaster, most of which is also formed in this manner. But the calcareous stalactites here spoken of consist of calcareous earth and fixed air; while the alabaster of the chemists is formed of the same earth and vitriolic acid, as has already been remarked.

ALBUM GRÆCUM. Innumerable are the instances of fanciful speculation, and absurd credulity, in the invention and application of subjects in the more ancient materia medica. The white and solid excrement of dogs, which subsist chiefly on bones, has been received as a remedy in the medical art, under the name of Album Græcum. It consists, for the most part, of the earth of bones, or lime in combination with phosphoric acid.

ALCHEMY. The practice of chemistry, comprehending every operation which is not mechanical, must of course have been among the earliest consequences of those efforts of the human mind which supply our wants, and distinguish civilized nations from the uncultivated. The various arts dependant upon this science were practised for ages before the systematic reasoning and inferences of philosophers had traced its dependances, and formed the science itself. Immediate profit is the object of pursuit in those who practise the arts; and while the several branches of chemical operation continued to be mere arts, their professors or practisers had in general no other views. It could not but happen, however, but that men of abilities would be found among these professors, who would reason well or ill upon what they saw; and as all reasoning with regard to natural appearances consists chiefly in the classing of similar phenomena, and deducing other events from them by analogy, it would follow of course that these men would discover rules, and establish general observations, by means of which their operations would be facilitated and extended. The spirit of trade would nevertheless intermix itself with their speculations, and lead them to consider their discoveries as lucrative secrets, not to be communicated but to others

of the same profession, whose successful researches had enabled them to afford other secrets in return. Thus it was that philosophic chemistry had its birth : in its infancy it was alchemy, a science whose professors were tradesmen, dazzled at the fruitful and extensive consequences to which their researches seemed to lead ; looking down upon and despising the common operator, who possessed no clue to lead him beyond the ordinary course of his business ; and extolling their own knowledge, which, from vanity as well as motives of profit, they either kept to themselves, or communicated in mysterious and enigmatical writings. The earliest philosophical writers on chemistry were alchemists, and distinguished themselves from common chemists by this appellation. As the true methods of philosophizing became better known, and liberality of sentiment increased, chemistry became a science in the hands of men of better taste and more enlightened judgment. The writings of the alchemists and their elevated professions continued notwithstanding to have their effects upon many persons, and are not entirely without their influence at the present instant. The efficacy of chemical preparations for medical use proved sufficient for a long time to enforce a certain degree of credit in favour of a panacea, or universal medicine, powerful to cure all diseases ; and a number of facts ill understood, and taken as the ground of extensive and plausible inferences, have induced numbers to believe that metals might be transmuted into each other. This last operation was chiefly aimed at the transmutation of metals of inferior price into gold. The pretence is still used by artful persons to impose on the ignorant, and in some instances, perhaps, by the ignorant, who impose on themselves.

ALCOHOL, or ALKOHOL. The purest ardent spirit, which contains less water than any other, is frequently called by this name.

ALEMbic, or STILL. This part of chemical apparatus, used for distilling or separating volatile products by first raising them by heat, and then condensing them into the liquid state by cold, is of extensive use in a variety of operations. It is described under the article **APPARATUS**, which see.

ALEMBROTH SALT. Corrosive sublimate is rendered much more soluble in water by the addition of sal ammoniac. From this solution crystals are separated by cooling, which were called sal alembroth by the earlier chemists, and appear to consist of volatile alkali, marine acid, and mercury ; but in what state the marine acid may be, whether the common or dephlogisticated, does not seem to have been ascertained.

ALGAROTH, POWDER OF. Among the numerous preparations which the alchemical researches into the nature of antimony have afforded, the powder of algaroth is one. When butter of antimony is thrown into water, it is not totally dissolved ; but part of the metallic calx falls down in the form of a white powder, which is the powder of algaroth. It is violently purgative, and emetic in small doses of three or four grains. See **ANTIMONY, and BUTTER OF ANTIMONY.**

ALKAHEST. The pretended universal solvent, or menstruum, of the ancient chemists. Kunckel has very well shewn the absurdity of searching for an universal solvent, by asking, “ If it dissolves all substances, in what vessels can it be contained ? ”

ALKALI. Modern chemistry has discovered many acids, and has succeeded in decomposing them into simpler substances, and recombining them. But the alkalis still remain in number only three ; and nothing has yet been effected to shew an unequivocal decomposition of the two fixed alkalis. The general characters in which the three alkalis agree are the following :

1. They have a peculiar taste, which is disagreeably caustic, even when diluted with water.

water. 2. They change blue vegetable colours to a green. 3. They have a very strong attraction for water, with which they unite in all proportions, and even attract it in sufficient quantities from the atmosphere to become fluid. 4. They combine with acids in the humid way, by a stronger affinity than is possessed in general by any other substances. 5. They melt in a moderate heat, and in a stronger heat they are volatilized. 6. In the dry way, they dissolve all earths and metallic calces.

The volatile alkali possesses the above general properties, except so far as its disposition to rise in the aeriform state at an heat less than boiling water, prevents its being exhibited in the dry way. Its affinities are also less strong.

Alkalis which contain fixed air are called mild alkalis.

The usual tests of alkalis are the tincture of turnsole, called litmus by the dyers, and the syrup of violets. But the knowledge of the habitudes of these bodies, like all others, can be but very imperfectly exhibited by general notions; because every one of the combinations into which they enter, does in fact exhibit some distinct elective attraction or property.

ALKALI, FIXED VEGETABLE. The vegetable alkali is found in some salts, which may be said to be of the mineral kingdom; but it is obtained for all the purposes of trade and science from vegetable matters. Of this there are several kinds, which differ only in the respective quantities, and nature of the impurities they contain. The cendres gravelées is a strong alkali made by burning the husks of grapes and wine lees. Potash is prepared by lixiviating wood ashes, and is very far from being pure. Most vegetables afford this alkali by burning them, and mixing their ashes with pure water, which after decantation or filtering may be evaporated, and will leave the salt behind. The purest is obtained by wrapping tartar in wetted brown paper, and placing the parcels in beds or strata alternately with charcoal in a furnace. The whole is then to be set on fire, and the fire continued till the blackening smoke ceases to arise. If the heat be too intense, the alkali will melt and mix with the impurities of the coal; but when the process is well conducted, the parcels may be taken out entire. By lixiviation or solution in pure water, with subsequent filtration, evaporation, drying, and calcining in a low heat, the alkali is obtained very white, and contains a considerable portion of fixed air. This might be driven off by heat; but such an increase of temperature would cause the alkali to dissolve the earth of the vessel, for which reason other methods are used. The vegetable alkali is known in the shops by the name of salt of tartar; but most chemists in London sell the impure alkali of potash by this name.

It is not easy to purify the common vegetable alkali met with in trade; and it is indeed seldom attempted. Neither is there any necessity in most operations that the chemist should employ his labour in procuring the alkalis absolutely disengaged from all other matter, as they will be equally useful if kept in combination, either with fixed air or with water; in which states the quantities may be more accurately ascertained by weight or measure when used, than if pure; because their rapid attraction for water in the latter case renders it almost impracticable to weigh them.

One of the readiest methods of obtaining the vegetable alkali in a state of considerable purity, consists in detonating common nitre in a crucible with charcoal. This salt consists of the vegetable alkali united with nitrous acid. If the finest prismatic nitre be fused, and made red hot in a crucible, and charcoal be then added by degrees, a most intense combustion takes place; during which the acid principle of the salt is dissipated, and the alkali is left in combination with fixed air only: that is to say, the vital air of the acid forms fixed air with the inflammable part of the charcoal.

coal, most of which fixed air unites with the alkali, while the phlogisticated air or other component part of the nitrous acid flies off. *See* ACID, NITROUS. More charcoal must be added as long as it continues to produce the vivid flame; and the heat must be raised towards the end, in order that the decomposition of the last portions of the nitre may be more completely effected. This salt has been improperly termed fixed nitre; but there is no difference between the pure specimens of this alkali, whatever subject it may have originally been obtained from.

To obtain the vegetable alkali in a state of great purity, the alkali of nitre by preference, or any other vegetable alkali, must be boiled for a short time with about twelve times its weight of water, and half its weight of quicklime, in a clean iron vessel. This lixivium must be filtered through paper supported by a cloth. If the clear fluid occasions no precipitation from lime-water, it is deprived of fixed air; but if not, it must be again boiled with the same quantity of quicklime, and filtered a second time. The clear liquor must then be exposed to evaporation in a retort, or long-necked vessel, in order that the emission of the steam may prevent the contact of the external air, from which the alkali would absorb a portion of fixed air, if the vessel were quite open or wide mouthed. The salt which remains consists, for the most part, of the vegetable alkali in a pure or caustic state, contaminated however with some other neutral salts, afforded in small quantities by the charcoal used in the detonation of the nitre, or by the principles of the vegetable substances made use of in obtaining the alkali, if nitre had not been used in the operation. To separate the pure alkali from these salts, a considerable quantity of ardent spirit must be added, which dissolves it totally. The decanted spirituous solution may in like manner be evaporated by distillation in a retort, and the salt left in a dry state. But as there are few occasions in which the salt may be wanted in this state, it may be dissolved in a small quantity of very pure water, and must be preserved in well closed vessels made of good glass. Several of the softer kinds of glass are so far altered by the action of very pure alkalis, that they crack and split in a variety of directions.

The ordinary vegetable alkali, whether obtained from tartar, or from nitre, is not saturated with fixed air, and deliquesces in the air. In this way, it attracts about three times its weight of water. The strong solution of this alkali is usually called oil of tartar per deliquium. Its action on the skin converts it into a kind of soap, which produces a sensation or feel of greasiness between the fingers, and has given rise to this appellation. But if it be exposed a sufficient time to the atmosphere, it absorbs a much larger quantity of fixed air, which neutralizes it, and in this state it may be obtained in permanent crystals. *See* AIR, FIXED.

A moderate red heat keeps the vegetable alkali in fusion with very little loss of quantity. A more violent fire, such as that of a smith's forge, or a wind furnace, volatilizes it, and even entirely dissipates the whole. No one has yet made the experiment of distilling or subliming the fixed alkali in a strong heat, so as to determine what change it may undergo in that process, if any. The vegetable alkali, when liquefied by heat, is a very powerful solvent. With earthy substances it forms glasses. Metals are not dissolved by it, but their calces readily unite with it. When the alkali is fused with any earth nearly in equal proportions, or still less of the alkali, it forms a combination which when cold is transparent, and resists the action of most solvents at a moderate temperature. This is the well-known composition called glass. *See* GLASS. When the alkali in fusion is three or four times the weight of the earth it may dissolve, the saline properties prevail, and the compound is soluble in

water. Siliceous earth, thus suspended in water by the medium of an alkali, is called the liquor of flints.

The vegetable fixed alkali unites with great energy to acids. With the vitriolic acid it forms the crystallizable salt called vitriolated tartar; with the nitrous acid it affords the common prismatic nitre; and with the marine acid it produces a salt which is known by the name of the salt of sylvius, or, improperly, regenerated sea salt. The other acids likewise afford peculiar combinations with this alkali, which are mentioned under their respective titles.

The fixed vegetable alkali also combines with inflammable substances. With sulphur, either in the humid or dry way, it forms liver of sulphur. With phosphorus it forms a peculiar hepatic compound. With oils it forms SOAP [which see]. It scarcely acts upon metallic substances in the dry way, unless calcined; and in the humid way, calcination seems likewise to be necessary for this purpose, either by the previous action of acids, or by the presence of vital air afforded by the atmosphere.

A considerable number of speculations have been entered into respecting the origin of the fixed alkalis. The vegetable alkali being mostly obtained by the incineration of plants or vegetable products, has been supposed to owe its formation to the fire. This however has never been proved; for the alkali afforded by tartar when burned is not greater in quantity than the same tartar affords when dissolved in water, and left to putrefy or suffer a spontaneous decomposition of its acid in an open vessel for many months. The salt of sorrel, the common nitre obtained from several plants, and vitriolated tartar, and even nitre found in the mineral kingdom, not to mention other instances, likewise exhibit this alkali in situations where it seems by no means to have undergone the process of incineration. It has been remarked, however, that in all the circumstances in which fixed alkali is afforded, there has been a previous exposure to vital air and phlogisticated air, and upon grounds little better than these it has been conjectured that the alkalis may consist of certain substances combined with vital, or perhaps with phlogisticated air. On the first of these suppositions, we should take alkalis to be bodies so eminently combustible, as to retain vital air by an attraction too strong to be overcome by any means we are acquainted with, and consequently not decomposable by art. And this eminent degree of combustibility would afford a reason for their strong attraction to acids, all of which contain vital air, and in particular to the dephlogisticated marine acid, upon which they act in so peculiar a manner as to deprive it of the surplus of vital air it contains; inasmuch that the salt formed on this occasion contains alkali, marine acid, and a much larger proportion of vital air, than the marine acid itself was capable of combining with; while the remaining portion of the aerated acid which afforded the vital air becomes converted into common marine acid, forming salt of sylvius with another portion of the alkali.

On the other hand, the knowledge we have acquired of the component parts of volatile alkali, which are phlogisticated and inflammable air, have led some chemists to consider phlogisticated air as the principle of alkalinity, in the same manner as vital air is taken to be the principle of acidity. This conjecture does not indeed so readily exhibit any analogy to explain the mutual action of alkalis and acids; but if the bases of fixed alkalis consist of either lime, magnesia, ponderous or even argillaceous earth, the known attraction of these substances for acids will be sufficient to account for the attraction exhibited by alkalis.

ALKALI, MINERAL. This fixed alkali, which is known in commerce by the name of barilla when in a less pure state, and by that of salt of soda when in clean crystals, is found in immense quantities in the mineral kingdom in combination with the marine acid, with which it forms sea salt; and likewise, though less plentifully,

tifully, in combination with the vitriolic acid in the form of Glauber's salt. As chemistry has not, however, invented any method sufficiently cheap to decompose these saline substances, the soda of commerce is principally obtained by the incineration of plants which grow on the sea shore, and lixiviation of their ashes, in the same manner as the fixed vegetable alkali is obtained from plants in general. It is found native on the ground in the island of Teneriffe, and elsewhere.

The mineral alkali in its ordinary state is so far neutralized by fixed air, that it crystallizes, and is so far from deliquescing by exposure to the atmosphere, that it even loses its water of crystallization, and falls into a dry powder. But when it is deprived of fixed air, it attracts moisture like the vegetable alkali, and cannot indeed be distinguished from that substance by any of its more obvious properties, though its habitudes with other substances, and the compounds it forms with them, are very different from those produced by the other fixed alkali.

The habitudes of mineral alkali in the fire are nearly the same as those of the vegetable. It dissolves earthy substances and metallic calces; and the glass it forms is said to be more solid and less alterable than that into which the vegetable alkali enters. Mineral alkali unites very powerfully with acids, though by a less affinity than that of the vegetable alkali, and the salts it forms differ very considerably from all others. With the vitriolic acid it forms Glauber's salt, as we have already taken notice; with the nitrous acid it forms quadrangular nitre, a salt that considerably resembles the common or prismatic nitre in its properties, and with the marine acid it produces the common sea salt. With the other acids it forms various combinations, which are described under their respective heads. This alkali likewise combines with inflammable substances, and forms a harder kind of soap with oils than is obtained by using the vegetable alkali.

The decomposition of common salt, for the purpose of obtaining the mineral alkali in great plenty and at a cheap rate, has been attempted by a great number of chemists. The most successful process is that of Scheele, who deprives it of its acid by the calx of lead or litharge. If a quantity of this calx be mixed with half its weight of common salt, then triturated with water till it assumes a white colour, and left to stand some hours, a decomposition ensues, the acid uniting with the metallic calx, and the alkali remaining disengaged. In this way, however, the alkali is not of sufficient value to pay the charges, and therefore the process is carried on to no greater extent than is required by the demand for the combination of lead and marine acid, which after it has been duly heated forms a fine greenish-yellow pigment.

Very little can be said from experiment concerning the intimate composition of the mineral alkali; and the conjectural inferences respecting this salt are nearly the same as those which have been slightly mentioned in the preceding article. It has been conjectured that lime is the basis of vegetable alkali, and magnesia of the mineral.

ALKALI, PHLOGISTICATED, or PRUSSIAN. When a fixed alkali is ignited with bullock's blood, or other animal substances, and lixiviated, it is found to be in a great measure saturated with the Prussian acid. From the theories formerly adopted respecting this combination, it has been distinguished by the name of phlogisticated alkali. The alkali cannot be conveniently saturated with the colouring matter, or Prussian acid, in any other way than by boiling it with Prussian blue. For a detail of its properties, *see* ACID OF PRUSSIAN BLUE; and also PRUSSIAN BLUE.

ALKALI, VOLATILE. The volatile alkali differs remarkably from the other two alkalis in its disposition to assume the aeriform state, and to rise by a moderate heat, even when combined with other substances. Its peculiar and pungent smell affords a distinctive criterion of its presence and disengagement. It is met with in the shops, either in a concrete form in combination with fixed air, in which state it is

usually called *sal volatile*, or improperly *volatile sal ammoniac*, or else in the fluid state combined with water, when it is usually distinguished by the appellation of spirit of *sal ammoniac* with lime, no doubt, because it is obtained by distilling those two substances together.

The volatile alkali is obtained during the destructive distillation of all animal substances which have not suffered putrefaction or spontaneous decomposition, and also from plants which are chiefly of the cruciform kind. Putrefaction likewise disengages it from these substances. It is found that all those bodies which afford volatile alkali by distillation do likewise afford phlogisticated air when treated with weak nitrous acid, and that the residue, thus deprived of its phlogisticated air, affords no volatile alkali, or much less than before; a circumstance which, among others, serves to indicate the composition of the volatile alkali, and that it does not exist ready formed in these substances, but is produced by the action of heat or putrefaction, which causes the phlogisticated air to unite with the inflammable air that plentifully exists in bodies of this kind. See AIR, PHLOGISTICATED.

The volatile alkali obtained by distillation from animal substances is contaminated with coaly matter and oil, and therefore in its first state possesses various properties, according to the nature of its impurities. These may be removed in various ways, but by none better than the addition of marine acid, which converts it into *sal ammoniac*.

Most of the volatile alkali is obtained from *sal ammoniac*. This salt was formerly imported from Egypt, where it is procured by sublimation from soot produced by burning the dung of camels. But it is now made in great plenty in Britain for the purpose of commerce. The volatile alkali is obtained in an impure liquid state by the manufacturers, who distil it from bones or soot, or any other substance that affords it. To this they add the mother water of vitriol; and also common salt in due quantities. The vitriolic acid first combines with the volatile alkali; but when the common salt, which consists of fixed mineral alkali and marine acid, is added, a change of the principles takes place by double elective attraction. The vitriolic acid seizes the mineral alkali, and forms the new compound, known by the name of Glauber's salt; while the marine acid unites with the volatile alkali, and forms *sal ammoniac*. By evaporation of the water, these salts are separated by crystallization, and the *sal ammoniac* is sublimed into cakes for sale.

In order to disengage the volatile alkali from *sal ammoniac* by distillation, it is necessary to add some fixed substance, which shall combine with and prevent the marine acid from rising. Chalk and flaked lime are the bodies commonly used. If a mixture of two parts of chalk and one of *sal ammoniac* in powder be exposed to a sand heat in a retort, with a receiver adapted, a change of principles by double affinity takes place. The chalk, which consists of lime and fixed air, is decomposed, and also the *sal ammoniac*. The lime unites with the marine acid, and forms a fixed earthy salt, which remains in the retort; and the fixed air unites with the volatile alkali, and passes into the receiver, where it appears in the form of a white hard salt of a pungent smell. This is the mild volatile alkali, or *sal volatile* of the apothecaries and perfumers. It is well known as a stimulant usually put into smelling bottles.

When lime or calcareous earth, deprived of fixed air, is made use of, the decomposition takes place as before; but the alkali rises in the form of alkaline air, and no part of the volatile product is condensed, until the water which may have been contained in the *sal ammoniac* or in the lime comes over. This water absorbs a quantity of the air, and forms the pure or caustic volatile alkali; but not, however,

before a considerable quantity of the alkaline air has been lost. Intelligent operators at present avoid this loss, by availing themselves of an apparatus of the same kind as is exhibited in figure 2, by the help of which the alkaline air being obliged to pass in contact with water in the receivers, is for the most part absorbed.

The volatile alkali has a much less strength of attraction in its combination than the fixed alkalis, and it is formed and decomposed in a variety of chemical operations. It unites very readily with acids, and forms salts which have been distinguished by the name of ammoniacal salts, and are noticed under their respective acids. It combines with oils, and much more readily with the essential than with the fixed oils. Spirit of wine dissolves it, as it does likewise its saponaceous compounds; but these compounds, though miscible with water, are scarcely soluble in that fluid. *See* *EAU DE LUCE*. Sulphur and phosphorus are acted upon by this alkali, though feebly. A sulphureous volatile hear is produced by the union of this alkali in the aerial state, with sulphur in the vaporous state. If equal parts of quicklime and sal ammoniac be mixed together with half a part of sulphur, and distilled with the pneumatic apparatus (fig. 2) with a small quantity of water in the receiver, a reddish yellow hepatic liquor will be obtained, which is the volatile hear, and was formerly known by the name of the fuming liquor of Boyle, so called from its inventor, and from the white fumes it emits in the air.

The volatile alkali combines with many of the metallic substances, though probably, in all cases, previous calcination, or the presence of vital air, may be necessary for this effect. Metallic precipitates thrown down by volatile alkali are mostly redissolved if an excess of alkali be added. For the habitudes of volatile alkali with metallic substances, *see* the Metals respectively.

The component parts of volatile alkali are phlogisticated air and inflammable air, in the proportions of six parts, by weight, of the former to one of the latter. On this subject consult *AIR, ALKALINE*; and also *ACID, NITROUS*, page 34.

ALKANET. The alkanet plant is a kind of bugloss, which is a native of the warmer parts of Europe, and cultivated in some of our gardens. The greatest quantities are raised in Germany and France, particularly about Montpellier, from whence we are chiefly supplied with the roots. These are of a superior quality to such as are raised in England. This root imparts an elegant deep red colour to pure spirit of wine, to oils, to wax, and to all unctuous substances. The aqueous tincture is of a dull brownish colour; as is likewise the spirituous tincture when inspissated to the consistence of an extract. The principal use of alkanet root is, that of colouring oils, unguents, and lip-salves. Wax tinged with it, and applied on warm marble, stains it of a flesh colour, which sinks deep into the stone; as the spirituous tincture gives it a deep red stain.

As the colour of this root is confined to the bark, and the small roots have more bark in proportion to their bulk than the great ones, these also afford most colour.

ALLAY, or ALLOY. Where any precious metal is mixed with another of less value, the assayers call the latter the alloy, and do not in general consider it in any other point of view than as debasing or diminishing the value of the precious metal. Philosophical chemists have availed themselves of this term to distinguish all metallic compounds in general. Thus brass is called an alloy of copper and zinc; bell-metal an alloy of copper and tin.

ALMONDS. Almonds consist chiefly of an oil of the nature of fat oils, together with farinaceous matter. The oil is so plentiful, and so loosely combined or mixed with the other principles, that it is obtained by simple pressure, and part of it may

be squeezed out with the fingers. There are two kinds of almonds, the sweet and bitter. The bitter almonds yield an oil as tasteless as that of the other, all the bitter matter remaining in the cake after the expression. Great part of the bitter matter dissolves by digestion, both in watery and spirituous liquors; and part arises with both in distillation. Bitter almonds are poisonous to birds, and to some animals. A water distilled from them, when made of a certain degree of strength, has been found from experiment to be poisonous to brutes; and there are instances of cordial spirits impregnated with them being poisonous to men. It seems, indeed, that the vegetable principle of bitterness in almonds and the kernels of other fruits is destructive to animal life when separated by distillation from the oil and farinaceous matter. The distilled water from laurel leaves appears to be of this nature, and its poisonous effects are well known.

ALOES. This is a bitter juice extracted from the leaves of a plant of the same name. Three sorts of aloes are distinguished in the shops, by the names of aloe soccotrina, aloe hepatica, and aloe caballina. The first denomination, which is applied to the purest kind, is taken from the island of Socotora; the second, or next in quality, is called hepatica, from its liver colour; and the third, caballina, from the use of this species being confined to horses. These kinds of aloes are said to differ only in purity, though, from the difference of their flavours, it is probable that they may be obtained in some instances from different species of the same plant. It is certain, however, that the different kinds are all prepared at Morviedro in Spain, from the same leaves of the common aloe. Deep incisions are made in the leaves, from which the juice is suffered to flow, and this, after decantation from its sediment, and inspissation in the sun, is exposed to sale in leathern bags by the name of soccotrine aloes. An additional quantity of juice is obtained by pressure from the leaves, and this, when decanted from its sediment and dried, is the hepatic aloes. And lastly, a portion of juice is obtained by strong pressure of the leaves, and is mixed with the dregs of the two preceding kinds to form the caballine aloes. The first kind is said to contain much less resin. The principal characters of good aloes are these: it must be glossy, not very black, but brown; when rubbed or cut, of a yellow colour; compact, but easy to break; easily soluble, of an unpleasant peculiar smell which cannot be described, and an extremely bitter taste.

Aloes appears to be an intimate combination of gummy and resinous matter, so well blended together, that watery or spirituous solvents, separately applied, dissolve the greatest part of both. It is not determined whether there be any difference in the medical properties of these solutions. Both are purgative, as is likewise the aloes in substance; and, if used too freely, are apt to prove heating, and produce hemorrhoidal complaints.

ALTHEA, or MARSH MALLOW. Two ounces of the dry root yielded, with water, ten drams fifty grains of mucilaginous extract; and afterwards, with spirit, forty-one grains of resin. The same quantity, treated with spirit, gave six drams of a resinous extract, a considerable portion of the mucilage dissolving in that menstruum along with the resin; the remainder, boiled in water, gave out five drams and forty-eight grains of pure mucilage. The insoluble matter amounts to somewhat more than one fourth of the weight.

ALUDEL. The process of sublimation differs from distillation in the nature of its product, which instead of becoming condensed in the fluid assumes the solid state, and the form of the receivers may of course be very different. The receivers for sublimates are of the nature of chimneys, in which the elastic products are condensed and adhere to their internal surface. It is evident that the head of an alembic will serve very well to receive and condense such sublimates as are not very volatile

volatile. The earlier chemists, whose notions of simplicity were not always the most perfect, thought proper to use a number of similar heads, one above the other, communicating in succession by means of a perforation in the superior part of each, which received the neck of the capital immediately above it. These heads differing in no respect from the usual heads of alembics, excepting in their having no nose or beak, and in the other circumstances here mentioned, were called aludels. They are seldom now to be seen in chemical laboratories, because the operations of this art may be performed with greater simplicity of instruments, provided attention be paid to the heat and other circumstances. *See APPARATUS.*

ALUM. This is a crystallizable salt composed of vitriolic acid united with argillaceous earth. It has an austere, sweetish, and strongly astringent taste, which seems to proceed chiefly from a portion of the vitriolic acid which is necessary to its solubility in water and crystalline form, though it be more than requisite to produce neutralization, as judged by the test of turnsole and blue paper, which it reddens. A considerable number of instances may be exhibited in chemistry where a superabundance of one of the two principles in compound salts is necessary to produce the finest crystals, and the most permanent combination. *See ACID OF TARTAR and ACID OF PHOSPHORUS.* If the excess of acid in alum be taken away, all the taste, the solubility, and the original properties of the salt, are lost.

One hundred parts of crystallized alum require, in a mean heat, about fourteen times its weight of water to dissolve it; but boiling water dissolves one third more than its own weight of this salt, most of which consequently separates by cooling. If crystallized alum be exposed to a gradual heat, it first becomes fluid by a kind of aqueous fusion, in which its own water of crystallization is the principal agent; the remaining mass, after most of the water has been expelled, grows opaque, swells, foams, and at length remains quiet, spongy, and friable. Ignition drives off some of its superabundant acid. The quantity of earthy basis in alum may be determined by precipitation with fixed or volatile alkali. In this way, however, there is a source of inaccuracy arising from the insolubility of the alum, which takes place as soon as its superabundant acid has combined with the alkali. At this period, a portion of the neutral combination of clay and vitriolic acid falls down without further decomposition. Long continued digestion in an alkaline lixivium is necessary to separate the whole of the acid. The volatile alkali is preferable in clearing the base of alum, because it would unite to fixed alkalis. The most commodious method of obtaining pure argillaceous earth consists in precipitating it in this manner from alum. *See EARTH, ARGILLACEOUS.*

In this way Bergman found one hundred parts of crystallized alum to contain forty-four of water, eighteen of clay, and consequently thirty-eight of vitriolic acid, and probably water, which could not be made to quit the acid.

Alum is produced, but in a very small quantity, in the native state; and this is mixed with heterogeneous matters. It effloresces in various forms, upon ores during calcination, but it seldom occurs crystallized. The greater part of this salt is factitious, being extracted from various minerals called alum ores, such as, 1. Sulphurated clay. This constitutes the purest of all aluminous ores, namely, that of la Tolfa, near Civita Vecchia, in Italy. It is white, compact, and as hard as indurated clay; from whence it is called *petra aluminaris*. It is tasteless and mealy: one hundred parts of this ore contain above forty of sulphur and fifty of clay, a small quantity of fixed vegetable alkali, and a little iron. Bergman says it contains forty-three of sulphur in one hundred, thirty-five of clay, and twenty-two of siliceous earth. This ore is first torrefied to decompose the sulphur, whose vitriolic acid reacts on the clay, and forms the alum.

2. The pyritaceous clay, which is found at Schwemfal, in Saxony, at the depth of ten or twelve feet. It is a black and hard, but brittle substance, consisting of clay, pyrites, and bitumen. It is exposed to the air for two years; by which means the pyrites are decomposed, and the alum is formed. The alum ores of Hesse and Liege are of this kind: but they are first torrefied, which is said to be a disadvantageous method.

3. The *shistus aluminaris* contains a variable proportion of petroleum and pyrites intimately mixed with it. When these last are in a very large quantity, this ore is rejected as containing too much iron. Professor Bergman very properly suggested, that by adding a proportion of clay this ore may turn out advantageously for producing alum. But if the petrol is considerable, it must be torrefied. The mine of Becker in Normandy, and those of Whitby in Yorkshire, are of this species.

4. Volcanic aluminous ore. Such is that of Solfaterra near Naples. It is in the form of a white saline earth, after it has effloresced in the air; or else it is in a stony form.

5. Bituminous alum ore is called shale, and is in the form of a *shistus*, impregnated with so much oily matter of bitumen as to be inflammable. Is found in Sweden, and also in the coal mines at Whitehaven, and elsewhere.

6. Alum might also be extracted from many species of pyrites; but so contaminated with iron as scarce to pay the expences of the operation.

The preparation of alum consists in rendering the ores aluminous in the first place, and next in dissolving and purifying the salt. Most of the alum ores contain clay and sulphur, which last requires to be converted into vitriolic acid before it can form the aluminous combination. For this purpose exposure to the air and occasional watering is effectual, and is in many places used: but it is less expeditious than the conversion of the sulphur into vitriolic acid by actual combustion. The chief difficulty of this process is, that the sulphur must be gradually and sufficiently burned without expelling it by too great a heat, which would likewise be attended with a fusion of the earthy parts that would render them capable of resisting the subsequent action of the water. After the ore has been, partly by calcination, and partly by spontaneous efflorescence, reduced to such a state as that it can be made into a paste by the hand, it is fit for boiling, which is usually performed in large leaden caldrons. In many manufactories a cold elixation is performed, until the saline solution is saturated; after which it is boiled until it be sufficiently strong for crystallization. This should not be too much loaded, because otherwise it would begin to deposit crystals by cooling before its earthy impurities had subsided. Some take the floating of a newly laid egg as a token of the boiling being finished; a rough method indeed, as well because the part above the liquor may be very different, and likewise because the specific gravity of eggs soon changes. The specific gravity of a fluid which just prevents a new laid egg from sinking is about 1.081.

The *lixivium*, sufficiently concentrated by evaporation, is conveyed through channels into coolers, where, in about an hour, it is freed, by deposition, from the grosser heterogeneous particles; it is then put into either stone or wooden receptacles. In eight or ten days the *lixivium*, commonly called *magistral water*, flows into another vessel, leaving behind a number of crystals, generally small and impure, which incrust the bottom and sides of the vessel. These are collected, and washed from the impurities which adhere externally with cold water: the impurities remaining in the reservoir after washing are kept by themselves.

The washed crystals are then put into the boiler used for purifying them, and are dissolved

dissolved in a quantity of water so small as barely to suspend the salt when boiling hot. The alum liquor is then poured into large strong wooden casks, whose staves and hoops are all numbered that they may be more readily put together. In these the alum gradually shoots into large crystals about the sides; the liquor in the middle is then let off by a cock in the bottom, and the vessel turned upside down for the more effectual draining of the remaining fluid. Lastly, the crystals are dried in a stove, and packed up in casks for sale.

In order to obtain the alum more pure at the second crystallization, some additions are employed in many of the manufactories, such as alkalis, lime, or urine. It is even asserted that good crystals of this salt cannot be obtained without such additions. We have not any clear account what it is that these additions perform. Urine is thought to be useful only by virtue of the volatile alkali it contains. It is thought that these additions engage with a superabundant acid, which from the decomposition of alum by alkaline substances does not seem to be the only use. As this proceeding is attended with advantage in the treatment of many kinds of aluminous lie, it seems not unlikely but that it may decompose vitriols and other metallic salts which might interrupt the crystallization of the alum, and at the same time render it impure. Thus martial vitriol, a salt frequently abounding in the alum ores after efflorescence, would be converted into calx of iron and selenite by the addition of lime; both which substances would fall down, on account of their very sparing solubility in that quantity of water which is sufficient to suspend the alum. So likewise the addition of potash, or the vegetable alkali, would produce calx of iron and vitriolated tartar, the latter of which requires a very considerable quantity of water to dissolve it. It is scarcely necessary to pursue these observations, as they would require to be varied according to the nature of the impurities in the lie, and other circumstances, among which the disposition to form triple combinations, which exhibits itself where a variety of principles are suspended in the same solvent, is not one of the least considerable.

In such cases (as it is ascertained that the alum is rendered more soluble, and consequently less crystallizable, by a superabundance of vitriolic acid) the most obvious and profitable remedy seems to be that of Bergman, who advises the addition of clay, which at the same time that it prevents the noxious superabundance, increases the quantity of alum. This should be added at the very first, when the lixivium is put into the boiler. All the lixivium may then be reduced to a tenacious mass, and formed into cakes, which may be exposed to the open air under a shed. In this situation the iron of the vitriol becomes more perfectly calcined by the action of the air, so as to retain its acid much less forcibly; which likewise, by its stronger attraction, is disposed to unite with the clay. Calcination accelerates this effect; but it must be cautiously employed for fear of expelling the acid. In all these manipulations, it is evident that much may be gained or lost in the treatment of alum ores, accordingly as the skill and intelligence of the manufacturer may lead him to employ such processes as are best suited to their contents*.

Alum is used in large quantities in many manufactories. It is extensively useful in the art of dying. When added to tallow, it renders it harder. Printers' cushions, and the blocks used in the calico manufactory, are rubbed with burnt alum to remove any greasiness which might prevent the ink or colour from sticking. Wood sufficiently soaked in alum does not easily take fire; and the same is true of paper impregnated with it, which is fitter to keep gunpowder, as it also excludes moisture.

* Consult Bergman on the preparation of alum.

Paper impregnated with alum is useful in whitening silver, and silvering brass without heat. Alum mixed in milk helps the separation of its butter. If added in a very small quantity to turbid water, in a few minutes it renders it perfectly limpid, without any bad taste or quality; whilst the vitriolic acid does not precipitate so soon, nor so well, the opaque earthy mixtures that renders it turbid, and gives to it a very sensible acidity, as I have often tried. It is used in making the pyrophorus, in tanning, and many other manufactories, particularly in the art of dying, in which it is of the greatest and most important use, by cleansing and opening the pores on the surface of the substance to be dyed, rendering it fit for receiving the colouring particles (by which the alum is generally decomposed), and at the same time making the colour fixed. Alum constitutes the basis of crayons, which generally consist of the earth of alum, finely powdered, and tinged for the purpose.

Alum is prepared in England, and many other parts of the world, and was formerly distinguished by various names. The rock alum is supposed to derive its name from an ancient city in Syria, called Roccho, at present Edeffa, where one of the earliest manufactories was carried on. The Roman alum has been considered as the best sort. It has a rosy-coloured tinge, which arises from about $\frac{1}{10}$ of its weight of a rose-coloured earth, the nature of which was not ascertained by Bergman, though he found that the goodness of the alum does not depend upon it. This alum is not preferred to other good alum by our manufacturers. Plume alum is a name given to two very different substances. The one appears to be true alum produced by the desiccation of aluminous waters, which transude through grottos and caverns, and leave this salt behind in feathery crystals. This is seldom met with. The other substance to which this name has been given, is the fibrous asbestos, which contains no alum; but from half to three fourths of its weight of siliceous earth, from one eighth to one third of mild magnesia, and the rest calcareous earth, with a minute proportion of clay, and sometimes iron.

ALUTA MONTANA. This is one of the names of the coriaceous asbestos, or mountain cork. It is easily distinguished by its elasticity and lightness, for it floats a long time on water. Its colour is either white, yellow, brown, green, or black; and its texture resembles those substances from which it has received its names: 100 parts of it contain from 56 to 62 of silex; from 22 to 26 of mild magnesia; from 10 to 12 of mild calcareous earth; from 2 to 2,8 of argil; and about 3 of iron.

AMALGAM. This name is applied to the combinations or mixtures of mercury with other metallic substances. As this metal is so exceedingly fusible as to be always in the fluid state in climates of a moderate temperature, it unites with many of the metals without any greater heat than that which it usually possesses. For this purpose, therefore, nothing more is necessary than to triturate thin leaves, or plates, or filings of the metallic substance with mercury. In other instances, where the disposition to combine is less powerful, it is found necessary either to fuse or ignite the metal intended to be amalgamated. When a small quantity of mercury is combined with any metal, it renders it brittle, or rather friable; a greater quantity of mercury produces a kind of imperfect fluidity resembling that of butter. This is commonly called the consistence of an amalgam. A still greater quantity of mercury renders the mass more fluid, but not uniformly so; for a portion of the amalgam either floats at the top, or sinks to the bottom, instead of intimately combining with the whole of the mercury. This fact is of the same kind as that wherein salts are soluble in water in limited quantities, beyond which they cease to be taken up. Mercury very readily combines with gold, silver, lead, tin, bismuth, and zinc. In

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making

making an amalgam of gold or silver, the clippings of the leaves from the gold-beaters may be used, or thin plates of the metals may be ignited, and plunged in mercury previously heated, so as to smoke. When the quantity of mercury is so large as to be fluid when cold, the superfluous mercury may be strained off by pressure through a leathern bag. The remaining amalgam of gold contains about one third of its weight of mercury, but is perfectly white. The amalgam of silver sinks in mercury, and consequently is heavier than either mercury or silver.

Mercury unites with difficulty into an amalgam with copper and arsenic; and scarcely at all with platina, or with iron. This latter metal, however, does not absolutely refuse to combine with mercury, for it adheres to and coats the ends of iron pestles used for the trituration of amalgams: and Dr. Lewis has observed, that a plate of tough iron is rendered brittle by keeping it immersed in mercury for some days; a fact which has been experienced in another way by Mr. de Luc, who found that springs immersed under mercury, in the construction of a barometer, were rendered brittle and useless by its action. Iron ignited to a white heat, and thrown into a large mass of mercury, becomes completely covered with a ferruginous bright amalgam. Regulus of antimony unites with mercury, though with great difficulty. Nickel and cobalt are said not to unite with mercury; and its action on manganese, wolfram, and molybdena, is not known.

Amalgams are applied to a considerable number of useful purposes. The amalgam of gold is used in the process called water gilding, in which the mercury first serves as the medium of adhesion between the gold and copper, and is afterwards driven off by heat. See GILDING. Looking glasses are silvered by an amalgam of tin. See SILVERING. The amalgam of zinc, triturated with tallow, is found to assist the excitation or production of electricity, by the friction of a cushion against glass, in a wonderful degree; inasmuch that the quantity of electricity is 20 or 30 times as great as without it.

When mercury is contaminated with any imperfect metal, it is found that by agitation, in contact with vital air, or the air of the atmosphere, the imperfect metal becomes converted into a black powdery calx, which separates from the mercury.

AMANDOLA. This is a green marble having the appearance of a honeycomb, and containing white spots: 100 parts of it contain 76 of mild calcareous earth; 20 of shifstus; 2 of iron, partly calcined. The cellular appearance proceeds from the * shifstus.

AMBER is a hard, brittle, tasteless substance, sometimes perfectly transparent, but mostly semi-transparent or opaque, and of a glossy substance: it is found of all colours, but chiefly yellow or orange, and often contains leaves or insects; its specific gravity is from 1,065 to 1,000; its fracture is even, smooth, and glossy; it is capable of a fine polish, and becomes electric by friction; when rubbed or heated, it gives a peculiar agreeable smell, particularly when it melts, that is at 550 of Fahrenheit, but it then loses its transparency; projected on burning coals it burns with a whitish flame, and a whitish yellow smoke, but gives very little soot, and leaves brownish ashes; it is insoluble in water and spirit of wine, though this latter, when highly rectified, extracts a reddish colour from it; but it is soluble in the vitriolic acid, which then acquires a reddish purple colour, and is precipitable from it by water; no other acid dissolves it, nor is it soluble in fixed alkalis, nor in essential

* Kirwan's Mineralogy.

nor expressed oils, without some decomposition and long digestion; but balsams dissolve it readily; 75 grains of it alkalize 100 of nitre; by distillation it affords a small quantity of water, an oil of the nature of petrol, and a peculiar acid. *See ACID OF AMBER.* Amber is met with plentifully in regular mines in some parts of Prussia. The upper surface is composed of sand, under which is a stratum of loam, and under this a bed of wood partly entire, but chiefly mouldered or changed into a bituminous substance. Under the wood is a stratum of vitriolic or rather aluminous mineral, in which the amber is found. Strong sulphureous exhalations are often perceived in the pits*.

Amber having been formerly considered as a valuable substance, and the specimens, which are large, or contain entire or perfect insects within them, being still of considerable price, the methods of softening it so as to introduce these extraneous bodies, or of uniting smaller pieces together, have been kept as profitable secrets, if it be true that they ever were discovered. It is said that two pieces of this substance may be united by wetting them with oil of tartar, and applying them together with heat; and Wallerius mentions, that pieces of yellow amber may be softened, formed into one, and even dissolved, by means of oil of turnip seed, in a gentle heat; and that, according to some authors, it may be rendered transparent by boiling in rape-seed oil, linseed oil, salt water, &c. Neumann, however, denies that either salt water or linseed oil produce this effect; though he states, as the common practices of workmen, the following methods: the one consists in surrounding the amber with sand in an iron pot, and cementing it with a gradual fire for forty hours, some small pieces placed near the sides of the vessel being occasionally taken out for judging of the effect of the operation; the second method, which he says is that most generally practised, is by digesting and boiling the amber about twenty hours with rape-seed oil, by which it is rendered both clear and hard.

There appears to be no doubt but amber is used in the making of varnishes, though probably in many instances the name may be used to recommend varnishes not really made of this substance. The same general views of profit have induced artists to conceal their methods of making these varnishes. The chief circumstance to be attended to in this process appears to consist in a previous roasting of the amber, by which its principles are altered in their arrangement, and it suffers a partial decomposition, which appears to be necessary to render it soluble in linseed oil, or essential oils; and it can hardly be doubted but that the quality of the varnish will be greatly affected by the degree of torrefaction, the heat of digestion, and other circumstances not easily determinable, except by trial and experience.

AMBERGRIS is found in the sea, near the coasts of various tropical countries; and is either white, black, ash-coloured, yellow, or blackish; or is variegated, namely grey with black specks, or grey with yellow specks. A slight warmth softens it like pitch; by a greater heat it takes fire; and its chemical products resemble those of bitumens, among which it has usually been ranked. Its smell is peculiar, and not easy to be counterfeited: linseed oil dissolves it by the assistance of heat; as does likewise strong ardent spirit at the heat of ebullition. The quantity taken up by ardent spirit is about $\frac{1}{12}$ part of its weight; and if the spirit be suffered to exhale by spontaneous evaporation, part of the dissolved matter separates in the form of a white

* Neumann's Chemistry.

unctuous substance resembling tallow, which however is taken up again upon the addition of more spirit.

It is at present a general opinion that ambergris is an excrementitious substance voided by the physeter-macrocephalus, or spermaceti whale. This is chiefly grounded on the enquiries and observations of Dr. Swedjar, in the Philosophical Transactions for the year 1783. Mr. Magellan, however, mentions an undoubtedly vegetable ambergris gathered from a tree which grows in Guyana, and is called Cuma. Specimens of this were presented to him by Mr. Aublet, author of the *Histoire de la Guyane*, published in 1774, who himself collected it on the spot; and Mr. Magellan presented part of it to the late Dr. Fothergill, and also to Dr. Combe. It is of a whitish brown colour with a yellowish shade; melts and burns like wax on the fire, but is rather of a more powdery consistence, says this author *, than any amber (or rather ambergris) he had seen.

AMETHYST. The amethyst is a gem of a violet colour and great brilliancy, said to be as hard as the ruby or sapphire, from which it only differs in colour. This is called the oriental amethyst, and is very rare. When it inclines to the purple or rosy colour, it is more esteemed than when it is nearer to the blue. These amethysts have the same figure, hardness, specific gravity, and other qualities, as the best sapphires or rubies, and come from the same places, particularly from Persia, Arabia, Armenia, and the West Indies. The occidental amethysts are merely coloured crystals or quartz.

AMMONIAC GUM. This is a gum resin, from an ounce of which six drams may be dissolved in ardent spirit, or six drams two scruples and a half by water, according to Newman.

AMMONIACAL SALTS. The combination of marine acid and volatile alkali is known by the name of sal ammoniac, a name which has been variously derived. By some it is taken from one of the Cyrenaic territories, Ammonia; by others from the temple of Jupiter Ammon; and by others from the Greek word which denotes sand, the salt being said to have been found plentifully in Ammonia, and near Ammon's temple, in sandy grounds. Salts containing the volatile alkali are very commonly called ammoniacal salts.

It is however a subject of controversy whether the sal ammoniac of the ancients was not of a different nature from that which we distinguish by the same name; and whether it was not marine salt or mineral alkali, as the true modern sal ammoniac is never found native, or at least not in any tolerably pure state. Common sal ammoniac is an artificial preparation formerly made only in Egypt; and its component parts were long known to the European chemists before any attempts were made to manufacture it here. By various accounts it is stated that the Egyptians procure it by sublimation from soot of cows' dung or camels' dung, urine, and common salt; but from subsequent accounts, transmitted to the Royal Academy at Paris, it appears to be incontrovertibly established, that this salt is procured by sublimation from the soot alone without any addition. The chimneys in which cow-dung only is burnt are said to furnish the best soot, and this yields between one fourth and one fifth of its weight of sal ammoniac; but in the general course of these operations the product is not more than one seventh of the whole weight of soot. The subliming vessels are of various sizes, the smallest containing about twelve pounds of soot, and the largest fifty; but they fill them only about three quarters full, in order to leave room for the sublimation of the salt.

* Magellan's *Cronstedt*, page 458.

The furnace in which these balloons are placed consists of four walls built in a quadrangular form. The two front walls are ten, and the sides nine feet long: but they are all five feet high and ten inches thick. Within the quadrangle formed by these walls, three arches run lengthwise from end to end thereof, at the distance of ten inches asunder. The mouth of this furnace is in the middle of one of its fronts, and of an oval form; two feet four inches high, and sixteen inches wide.

The balloons lie in the spaces between the arches of the furnace, which serve instead of a grate to support them. Four of them are usually placed in each interval, which makes sixteen for one furnace. They are set at the distance of about half a foot from each other, and secured in their places with brick and earth: but they leave about four inches on the upper part of the balloon uncovered, with a view to promote the sublimation, as they also do six inches of the inferior part, that the heat may the better act on the matter to be sublimed. Things being thus prepared, they first make a fire with straw, which they continue for an hour. Afterwards they throw in cows' dung made up in square cakes like bricks. (The want of wood in this country is the reason that they generally make use of this fuel.) These cakes of dung add to the violence of the fire, which they continue in this manner for nineteen hours; after which they increase it considerably for fifteen hours more, and then they slacken it by little and little.

When the matter contained in the vessels begins to grow hot, that is, after six or seven hours baking, it emits a very thick and ill-scented smoke, which continues for fifteen hours. For hours after that the sal ammoniac is observed to rise in white flowers, which adhere to the inside of the neck of the vessel; and those who have the direction of the operation take care, from time to time, to pass an iron rod into the neck of the balloon, in order to preserve a passage through the saline vault for giving vent to some blueish vapours, which constantly issue out of the vessel during the whole operation*.

The preparation of sal ammoniac, in the European manufactories, has been already mentioned under the article of ALKALI, VOLATILE, which see.

The taste of sal ammoniac is penetrating, acrid, and urinous. The form of its crystals is that of a six-sided, very long pyramid, the union of which causes the sublimed salt to possess a striated texture. This salt is remarkably deficient in that degree of brittleness which characterizes saline crystals. It appears to be in some measure flexible, and has so much elasticity, that it rebounds under the stroke of a hammer, and cannot without difficulty be pulverized, or broken into small pieces. This salt is totally volatile, though it requires a considerable heat to raise it, nearly the same as melts lead. This is the best method of purifying sal ammoniac. It seems, however, by reports of some of the earlier chemists, that repeated sublimations alter the properties of this salt, and render it less consistent. This fact requires to be more particularly examined, before any explanation can with propriety be offered. It is not improbable, however, that part of the volatile alkali may be decomposed in these repeated sublimations; the consequence of which would be, that the remaining salt would possess a redundancy of acid.

Sal ammoniac suffers no change by long exposure to the air. It is very soluble in water, six parts of that fluid being sufficient, at a common temperature, to dissolve one of the salt. This solution produces a very considerable depression of temperature: an effect which always takes place on the speedy solution of saline crystals, and appears to depend on the transition of their water of crystallization from a solid

* Lemaire and Granger, quoted by Macquer in his Elements of Chemistry, II. 391.

to a fluid state. *See* HEAT. Boiling water dissolves nearly its own weight of sal ammoniac, and deposits crystals by cooling; though the most regular crystals of this, as well as other salts, are obtained by spontaneous evaporation.

Sal ammoniac is not decomposed by clay, and difficultly by magnesia; lime, ponderous earth, and the fixed alkalis, decompose it, as well in the humid as in the dry way, by combining with its acid. The vitriolic and nitrous acids seize its alkali. It detonates with nitre, no doubt by the decompositions of the volatile alkali and nitrous acid. Hence it should appear, that the residue will consist of common salt, and the volatile product will be chiefly phlogisticated air. But these facts require to be more particularly examined.

Sal ammoniac is made use of in medicine, and is extensively useful in various businesses; such as dyers, glass makers, and more particularly those who work in metals, for soldering, or causing one metal to adhere to the surface of another. *See* SOLDERING; TINNING.

AMMONITES. This petrification, which has likewise been distinguished by the name of cornu ammonis, and is called the snake stone by the vulgar, consists chiefly of lime-stone, or mild calcareous earth. They are found of all sizes, from the breadth of half an inch to more than two feet in diameter; some of them rounded, others greatly compressed, and lodged in different strata of stones and clays. They appear to owe their origin to shells of the nautilus kind.

AMOMUM. *See* PIMENTO.

AMPELYTES. A solid, dry, hard, opaque, black, fossil coal, not fusible, but easily inflammable, and burning with a bright vivid white flame, with much smoke, and a bituminous or pitchy smell. In the north of England it is called cannel coal, perhaps by corruption, instead of candle coal, as it is used to supply the place of candles in poor families. An alum ore found in Burgundy, and consisting of clay, pyrites, and bitumen, is also distinguished by this name.

AMYGDALOIDES, or MANDEL-STEIN. A stone of the siliceous genus, which consists of a martial jasper, in which elliptical kernels of calcareous spar and serpentine stone are included.

ANALYSIS. The chemical analysis consists of a great variety of operations performed for the purpose of separating component parts of bodies. In these operations, the most extensive knowledge of such properties of bodies as are already discovered must be applied, in order to produce simplicity of effect and certainty in the results. The chemical analysis can hardly be made with success by one who is not in possession of a considerable number of simple substances in a state of great purity, many of which, from their effects, are called re-agents. The word analysis is applied by chemists to denote that series of operations by which the component parts of bodies are determined, whether they be merely separated, or exhibited apart from each other; or whether these distinctive properties are exhibited, by causing them to enter into new combinations, without the perceptible intervention of a separate state. The forming of new combinations is called synthesis; and, in the chemical examination of bodies, analysis or separation can scarcely ever be effected without synthesis taking place at the same time.

As most of the improvements in the science of chemistry consist in bringing the art of analysis nearer to perfection, it is not easy to give any other rule to the learner, than the general one of consulting and remarking the processes of the best chemists, such as Scheele, Bergman, Berthollet, Kirwan, and others. The bodies which present themselves more frequently for examination than others, are minerals and mineral waters. In the examination of the former, it was the habit of the earlier chemists

mists to avail themselves of the action of fire, with very few humid processes, which are such as might be performed in the usual temperature of the atmosphere. Modern chemists have improved the process by fire, by a very extensive use of the blow-pipe (*see* BLOW-PIPE); and have succeeded in determining the component parts of minerals to great accuracy in the humid way. For the method of analysing mineral waters, *see* WATERS, MINERAL; and for the analysis of metallic ores, *see* the respective metals.

Several authors have written on the examination of earths and stones: the following is the method of Mr. Kirwan.

When earths, or pulverulent mineral substances, are well dried, and separated from every visible heterogeneous substance, a portion of them should be weighed, and distilled in a glass retort until the bottom begins to grow red hot. In some cases it may be proper to receive the air that arises in a pneumatic apparatus; and in all it will be proper to examine what distills over or sublimes, whether it be acid or alkaline, with paper tinged blue by litmus, and part of its surface reddened by distilled vinegar. If the blue be reddened, an acid exists in the distilled liquid; if the red be effaced, and the blue restored, a volatile alkali is the cause of it; if the liquor precipitates lime-water, but does not precipitate a solution of nitrous selenite, or the salt formed by lime and nitrous acid, then it contains fixed air; if it precipitates also nitrous selenite, it contains the vitriolic acid; if it contains the marine acid, it will not precipitate nitrous selenite, but it will the nitrous solution of silver. The loss of weight of the residuum in the retort, and the weight of water in the receiver, will shew the proportion of the volatile ingredients.

Another portion of the earth to be examined should be digested in about six or eight times its weight of pure water, and the properties of that water examined to find whether the earth contains neutral salts. *See* WATERS, MINERAL.

The first step in the examination of consistent earths or stones is somewhat different from that of such as are pulverulent. Their specific gravity should first be examined; also their hardness, whether they will strike fire with steel, or can be scratched by the nail, or only by crystal, or stones of still greater hardness; also their texture, perviousness to light, and whether they be manifestly homogeneous or compound species, &c.

2d. In some cases, one should try whether they imbibe water, or whether water can extract any thing from them by ebullition or digestion.

3d. Whether they are soluble in, or effervesce with, acids, before or after pulverization; or whether decomposable by boiling in oil of tartar, &c. as gypsums and ponderous spars are.

4th. Whether they detonate with nitre.

5th. Whether they yield the sparry acid by distillation with oil of vitriol, or a volatile alkali by distilling them with salt of tartar.

6th. Whether they are fusible per se with a blow-pipe, and how they are affected by mineral alkali, borax, and microcosmic salt; and whether they decrepitate when gradually heated.

7th. Stones that melt per se with the blow-pipe are certainly compound, and contain at least three species of earth, of which the calcareous is probably one; and if they give fire with steel, the siliceous is probably another.

The best general solvent for stones or earths appears to be aqua regia, composed of two parts nitrous and one of marine acid: if the stone or earth effervesces strongly with acids, no other preparation is requisite than a separation of such parts as are visibly heterogeneous, and pulverization; the solution is then easily performed in a digesting

digesting heat, if requisite. The undissolved residuum, if purely siliceous, will melt into a transparent glass with about $\frac{1}{2}$ its weight of mineral alkali; if not, it is still compounded, and its soluble parts will yield to a reiterated digestion.

If the stone does not effervesce, or easily dissolve in acids after pulverization and digestion, but leaves an insoluble residuum evidently compound, or but slightly altered, it will require to be pulverized, and mixed with twice or thrice its weight of mineral alkali, and to be exposed to a low red heat for one or two hours. Mica was found to require a mixture of 4 times its weight of mineral alkali; after which it is to be separated from the alkali by lixiviation and filtration, washing it with distilled water until the water is absolutely tasteless, and precipitates no metallic solution.

The powdered stone, thus edulcorated, is to be dried by heating it to redness, and then weighed, and 100 grains taken for subsequent experiments: it were better if still more were used, but the analysis would be more expensive.

The powder is next to be digested in 8 or 10 times its weight of aqua regia, in a boiling heat, in a retort to which a receiver is luted, and the digestion reiterated as long as any thing appears to be dissolved by fresh portions of the acid. Mica was found to require 50 times its weight of aqua regia before it was entirely decomposed, as the acid is so volatile as very soon to distil over. Oil of vitriol has the advantage of bearing a greater heat, dissolving ponderous spar, and of acting more powerfully on clay than aqua regia; but a large retort must be used, for often towards the end it puffs and throws up the earth or stone, and carries it into the receiver; besides, it does not sufficiently act on calces of iron, if these be much dephlogisticated. Spirit of nitre affects them still less: hence Mr. Kirwan often uses oil of vitriol first, then what has been dissolved he precipitates by a mild alkali, and re-dissolves the precipitate in aqua regia. A perfect solution being thus effected, the residuum is to be well washed, and the washings added to the solution: the residuum, well dried and weighed, gives the weight of siliceous earth in the compound.

The solution is next to be examined; which we will suppose to contain the four soluble earths, calcareous, ponderous, magnesian, and argillaceous, and also a calx of iron. It always contains an excess of acid, of which it is in great measure deprived by boiling for a considerable time, as both acids are very volatile, and indeed of the marine none remains but what is combined with the calx of iron, as the nitrous chafes it from the earths. By getting rid of this excess of acid, less alkali will be required for the succeeding precipitation, and less aerial acid set loose which would retain much of the precipitate by re-dissolving it: the solution should then be evaporated to about half a pint.

The solution being thus prepared, it is usual to precipitate the calx of iron from it by the Prussian alkali; but to this method Mr. Kirwan has two objections: 1st. that the ponderous earth, if any, would also be precipitated and confounded in the Prussian blue; and 2d. that this precipitation, besides being exceeding slow, seldom fails of leaving some iron still in the solution, as the excess of the Prussian alkali, which must necessarily be added to be certain that all the iron is precipitated, never fails to re-dissolve a portion of the Prussian blue which thus remains in the liquor and cannot be got rid of. Hence the method he uses is as follows: First, he prepares the Prussian alkali after the manner of Mr. Bergman, by digesting and boiling a pure alkaline solution over Prussian blue, until the alkali no longer effervesces with acids, nor precipitates a solution of nitrous selenite, or any other earth, except the barytes: he even makes it a little stronger; for if it be barely saturated with the tinging matter, it soon spoils and precipitates other earths; the tinging matter evaporating,

porating, he next examines how much of this alkali is necessary to precipitate one grain of iron from its solution in dilute vitriolic or marine acid, and marks this on the label of the bottle that contains the alkali. Next follows the application.

The solution of the earths being weighed, take 100 grains of it, and on these gradually pour the Prussian alkali (a portion of which is also previously weighed), until all the iron, or ponderous earth and iron, is precipitated; the weight of the alkali used gives that of the iron contained in 100 grains of the solution, and the quantity contained in 100 grains of the solution gives that contained in the whole solution, by the rule of proportion, from which the ponderous earth, if any be found in subsequent experiments, is to be deducted.

The quantity of iron being thus found, the remainder of the solution is to be precipitated by aerated or mild mineral alkali, and then boiled for half an hour, to expel as much as possible of the fixed air; by this means the whole of its contents are precipitated, and nothing remains in solution but cubic nitre and a little common salt: when the precipitate has settled, after one or two days rest, the liquor is to be poured off, and the last portions taken up with a glass syringe. Distilled water is then to be added to the precipitate, and boiled over it, and afterwards poured off, and taken up until it comes off tasteless.

The precipitate being sufficiently dried, is to be re-dissolved in nitrous acid twice, and evaporated to dryness; then calcined for one hour in a white heat; and, lastly, treated with about six or eight times its weight of distilled vinegar, in a heat of about 60 degrees, for one or two hours: by this means the ponderous, calcareous, and magnesian earths will be extracted and separated from the clay and calx of iron, which will remain undissolved.

Of this acetous solution 100 grains should be taken and examined with the Prussian alkali: if any part be precipitated it is ponderous earth, and by heating this to redness its weight may be known; or still better, by a previous experiment determining the quantity requisite to precipitate one grain of acetous baroselenite, and, by the rule of proportion, the quantity of it in the whole solution may be found.

The remainder of the acetous solution is to be evaporated to dryness, and heated white in a clean polished iron crucible for two hours, then weighed and thrown into hot distilled water: the calcareous earth (if any) will be dissolved in a sufficient quantity of this water, of which an ounce can scarcely dissolve one grain, so that frequent affusions of hot water may be requisite; the magnesia will remain undissolved, and is to be dried and weighed; its weight gives that of the pure calcareous earth, from which that of the ponderous (if any) is to be deducted: the lime-water may also be precipitated by an aerated alkali.

Lastly, the clay, and calx of iron, which remained undissolved by the acetous acid, are to be heated slightly, to prevent their cohering, and reiteratedly boiled in dephlogisticated nitrous acid to dryness, and finally dissolved in that acid, which will then take up only the clay, which may be precipitated, dried, and weighed; though indeed this troublesome operation may be unnecessary, as the weight of the martial part being known by the experiment with the Prussian alkali, that of the clay is known of course when only the two remain. This is even better, as the calx always increases in weight by these operations.

Besides this general method, some others may be used in particular cases.

Thus, to discover a small proportion of argillaceous earth or magnesia in a solution of a large quantity of calcareous earth, caustic volatile alkali may be applied, which will precipitate the clay or magnesia (if any be), but not the calcareous earth. Distilled vinegar applied to the precipitate will discover whether it be clay or magnesia.

2dly. A minute portion of calcareous or ponderous earth, in a solution of argillaceous earth or magnesia, may be discovered by the vitriolic acid which precipitates the calcareous and ponderous: the solution should be dilute, else the clay also would be precipitated. If there be not an excess of acid, the saccharine acid is still a nicer test of calcareous earth: 100 grains of gypsum contain about 32 of calcareous earth; 100 grains of barofelenite contain 84 of ponderous earth; 100 grains of saccharine felenite contain 45 of calcareous earth. The insolubility of barofelenite in 500 times its weight of boiling water sufficiently distinguishes it. From these data the quantities are easily investigated.

3dly. A minute proportion of argillaceous earth in a large quantity of magnesia may be discovered either by precipitating the whole, and treating it with distilled vinegar, or by heating the solution nearly to ebullition, and adding more aerated magnesia until the solution is perfectly neutral, which it never is when clay is contained in it, as this requires an excess of acid to keep it in solution. By this means the clay is precipitated in the state of embryon alum, which contains about half its weight of clay (or for greater exactness it may be decomposed by boiling it in volatile alkali). After the precipitation the solution should be largely diluted, as the Epsom salt, which remained in solution while hot, would precipitate when cold, and mix with the embryon alum.

4thly. A minute portion of magnesia in a large quantity of argillaceous earth is best separated by precipitating the whole, and treating the precipitate with distilled vinegar.

Lastly, Calcareous earth and barytes, or ponderous earth, are separated either by precipitating the barytes by the Prussian alkali, or the calcareous by a caustic fixed alkali, or by precipitating both with the vitriolic acid, and evaporating the solution to a small compass, pouring off the liquor, and treating the dried precipitate with 500 times its weight of boiling water; what remains undissolved is barofelenite, or ponderous spar.

ANGELICA. The roots have a pungent agreeable bitterish taste, and a strong aromatic smell, somewhat of the musky kind. Their activity resides in an essential oil and a resinous matter. The oil is obtained by distillation with water. The oil and the resin are totally extracted by digestion in ardent spirit; and water by the like treatment extracts them, though in part only.

These roots, like those of most of the umbelliferous plants, are very apt to be preyed upon by worms, to become carious, and fall into powder. So long as they are merely worm-eaten, and not powdery, they are as fit for making the essential oil, or the tinctures in ardent spirit or water, as in their most perfect state; the insects preying first upon the mucilaginous and insipid parts, and not upon the resinous and oily parts. When such roots are made use of, care must be taken to beat out the worms and dust as much as possible. To preserve the roots of Angelica, they must be thoroughly dried, and kept in close vessels or packages in a dry place.

ANIL, or NIL. This plant, from the leaves of which indigo is prepared, grows in America. It has several slender knotty stalks which spread into small branches, clothed each with from four to ten pair of leaves, and an odd one at the end. The leaf is small, fleshy, and soft, of a greenish brown colour on the upper side, pale and as it were silvery-coloured beneath. The plant rises to the height of about two feet, and produces reddish flowers, in shape resembling those of broom, but smaller, followed by oblong pods containing the seeds.

The culture of this plant is as follows*: The ground being thoroughly cleared

* Labat, quoted by Lewis on Neumann, II. 237.

of weeds, which is a principal object, a number of slaves, ranged in a line, march across, making little trenches of the width of their hoes, and two or three inches deep, about a foot distant from each other every way. Then returning, they drop some seeds in each trench, and afterwards cover them with the earth taken out. In moist weather the plant comes up in two or three days; and in about two months it is fit for cutting. If suffered to stand till it runs into flower, the leaves become too dry and too hard, and the indigo obtained from them proves less in quantity and less beautiful. The due point of maturity is known by the leaves beginning to grow less supple or more brittle. In a rainy season the cutting may be repeated every six weeks. Cutting in dry weather kills the plant, which, if that is avoided, continues to afford fresh crops for two years. For the preparation of *INDIGO*, see that article.

ANIMAL KINGDOM. The various bodies around us, which form the objects of chemical research, have all undergone a number of combinations and decompositions before we take them in hand for examination. These are all consequences of the same attractions or specific properties that we avail ourselves of, and are modified likewise by virtue of the situations and temperatures of the bodies presented to each other. In the great mass of unorganized matter, the combinations appear to be much more simple than such as take place in the vessels of organized beings, namely plants and animals: in the former of which there is at least a peculiar structure of tubes conveying various fluids; and in the latter there is not only a most elaborate system of vessels, but likewise for the most part an augmentation of temperature. From such causes as these it is that some of the substances afforded by animal bodies are never found either in vegetables or minerals; and so likewise in vegetables are found certain products never unequivocally met with among minerals. Hence, among the systematical arrangements used by chemists, the most general is that which divides bodies into three kingdoms, the animal, the vegetable, and the mineral.

Animal as well as vegetable bodies may be considered as peculiar apparatus for carrying on a determinate series of chemical operations. Vegetables seem capable of operating with fluids only, and at the temperature of the atmosphere, as we have just noticed. But most animals have a provision for mechanically dividing solids by mastication, which answers the same purpose as grinding, pounding, or levigation does in our experiments; that is to say, it enlarges the quantity of surface to be acted upon by solvents. The process carried on in the stomach appears to be of the same kind as that which we distinguish by the name of digestion; and the bowels, whatever other uses they may serve, evidently form an apparatus for filtering or conveying off the fluids; while the more solid parts of the aliments, which are probably of such a nature as not to be rendered fluid, but by an alteration which would perhaps destroy the texture of the machine itself, are rejected as useless. When this filtered fluid passes into the circulatory vessels, through which it is driven with considerable velocity by the mechanical action of the heart, it is subjected not only to all those changes which the chemical action of its parts is capable of producing, but is likewise exposed to the air of the atmosphere in the lungs, into which that elastic fluid is admitted by the act of respiration. Here it undergoes a change of the same nature as happens to other combustible bodies when they combine with its vital part. This vital part becomes condensed, and combines with some principle emitted from the blood; at the same time that it gives out a large quantity of heat, in consequence of its own capacity for heat being diminished. It has not been ascertained whether the substance which converts the inspired vital air into fixed air (of which a portion is ex-

pired from the lungs together with the noxious or phlogificated air) be inflammable air or charcoal; and it has likewise been doubted whether any part of the vital air is absorbed by the blood. Later experiments of Dr. Priestley shew however that this last event does actually take place*.

It would lead us too far from our purpose, if we were to attempt an explanation of the little we know respecting the manner in which the secretions or combinations that produce the various animal and vegetable substances are effected, or the uses of those substances in the economy of plants and animals. Most of them are very different from any of the products of the mineral kingdom. We shall therefore only add, that these organized beings are so contrived, that their existence continues, and all their functions are performed, as long as the vessels are supplied with food or materials to occupy the place of such as are carried off by evaporation from the surface, or otherwise, and as long as no great change is made, either by violence or disease, in those vessels or the fluids they contain. But as soon as the entire process is interrupted in any very considerable degree, the chemical arrangements become altered; the temperature in land animals is changed, the minute vessels are acted upon and destroyed, life ceases, and the admirable structure, being no longer sufficiently perfect, loses its figure, and returns, by new combinations and decompositions, to the general mass of unorganized matter, with a rapidity which is usually greater, the more elaborate its construction.

The parts of vegetable or animal substances may be obtained, for chemical examination, either by simple pressure, which empties the vessels of their contents; by digestion in water, or in other fluids, which dissolve certain parts, and often change their nature; by destructive distillation, in which the application of a strong heat alters the combination of the parts, and causes the new products to pass over into the receiver in the order of their volatility; by spontaneous decomposition or fermentation, wherein the component parts take a new arrangement, and form compounds which did not for the most part exist in the organized substance; or, lastly, the judicious chemist will avail himself of all these several methods singly, or in combination. He will, according to circumstances, separate the parts of an animal or vegetable substance by pressure, assisted by heat; or by digestion or boiling in various fluids added in the retort which contains the substance under examination. He will attend particularly to the products which pass over, whether they be permanently elastic, or subject to condensation in the temperatures we are able to produce. In some cases he will suffer the spontaneous decomposition to precede the application of chemical methods; and in others he will attentively mark the changes which the products of his operations undergo in the course of time, whether in closed vessels, or exposed to the open air. Thus it is that, in surveying the ample field of nature, the philosophical chemist possesses numerous means of making discoveries, if applied with judgment and sagacity; though the progress of discovery, so far from bringing us nearer the end of our pursuit, appears continually to open new scenes, and, by enlarging our powers of investigation, never fails to point out additional objects of enquiry.

Animal and vegetable substances approach each other by insensible gradations; so that there is no simple product of the one which may not be found in greater or less quantity in the other. The most general distinctive character of animal substances is that of affording volatile alkali by destructive distillation. Some plants however afford it likewise. Neither contain it ready formed; but it appears to be

* Phil. Trans. lxxx. 106.

produced by the combination of phlogisticated and inflammable air, during the changes produced either by fire, or by the putrefactive process. See ALKALI, VOLATILE; and AIR, PHLOGISTICATED.

Few of the products of the animal kingdom have been subjected to chemical analysis. For this reason it is not practicable to arrange them according to the nature of their component parts. Animal substances may therefore be conveniently divided into, 1. Such as are usually obtained without destroying life. These are milk, eggs, urine, excrement, the matter of perspiration, ambergris, &c. wax, honey, gum-lack, silk, hair, horn, feathers, &c. Or, 2. Such parts of animals as are obtained by destroying them, or depriving them of life. These are blood; various solids confounded under the name of flesh, fat, spermaceti, bile, the gastric juice, and several acids; together with calcareous earth, and other substances common to the mineral and vegetable kingdoms. For the properties of which, see the respective articles.

When animal substances are left exposed to the air, or immersed in water or other fluids, they suffer a spontaneous change, which is more or less rapid according to circumstances. The spontaneous change of organized bodies is distinguished by the name of fermentation. In vegetable bodies there are distinct stages or periods of this process, which have been divided into the vinous, acetous, and putrefactive fermentations. Animal substances are susceptible only of the latter, during which, as in all other spontaneous changes, the combinations of chemical principles become in general more and more simple. There is no doubt but much instruction might be obtained from accurate observations of the putrefactive processes in all their several varieties and situations; but the loathsomeness and danger attending on such enquiries has hitherto greatly retarded our progress in this department of chemical science. See FERMENTATION.

ANIME, improperly called gum anime, is a resinous substance imported from New Spain and the Brazils. There are two kinds, distinguished by the names of oriental and occidental. The former is dry, and of an uncertain colour, some specimens being greenish, some reddish, and some of the brown colour of myrrh. The latter is in yellowish, white, transparent, somewhat unctuous tears, and partly in larger masses, brittle, of a light pleasant taste, easily melting in the fire, and burning with an agreeable smell. Like resins it is totally soluble in ardent spirit, and also in oil. Water takes up about $\frac{1}{10}$ of the weight of this resin by decoction. The spirit drawn off by distillation has a considerable degree of the taste and flavour of the anime; the distilled water discovers on its surface some small portion of essential oil.

This resin is used by perfumers, and also in certain plasters, wherein it has been supposed to be of service in nervous affections of the head and other parts; but there are no reasons to think that, for medical purposes, it differs from common resins.

ANISEED contains, besides its essential odorous oils, a gross one of the expressible kind. The essential oil, and the smell and taste of the seeds which depend upon it, are confined to the outer thin skin: the inner kernel, which is commonly divided longitudinally into two portions, has little or no smell, and exceeding little taste: in this resides the gross oil, naturally inodorous and insipid, but which, nevertheless, in its separation from the seed by the press, brings with it a part of the essential oil, so as to become strongly impregnated with the peculiar flavour of the aniseed; its colour is greenish.

The essential oil, though mild in taste, has an extremely strong smell, which it communicates.

communicates to whatever it touches in such a degree as scarcely to be overpowered. It coagulates in a temperature much warmer than is necessary to freeze water. The term of its congelation, which seems to be about 50 degrees of Fahrenheit's thermometer, but is not very easy to be determined with great accuracy, because it is a bad conductor of heat, was proposed by Boyle, in the infancy of the thermometer, to be used as a fixed point in the graduation of that instrument. This oil, like other essential oils, is soluble in ardent spirit, from which it in part separates by cooling. Neumann observes that it dissolves sulphur in greater quantity than any other oil expressed or distilled. Another singular fact is noticed by the same author, viz. that whereas the distillation of essential oil from other vegetables is in general facilitated by the addition of salt to the water which is added to the vegetable substance, such an addition is particularly hurtful in this process, the aniseed yielding only half as much oil as it does when distilled with pure water.

ANNEAL. We know too little of the arrangement of particles to determine what it is that constitutes or produces brittleness in any substance. In a considerable number of instances of bodies which are capable of undergoing ignition, it is found that sudden cooling renders them hard and brittle. This is a real inconvenience in glass, and also in steel, when this metallic substance is required to be soft and flexible. The inconveniences are avoided by cooling them very gradually, and this process is called annealing. Glass vessels, or other articles, are carried into an oven or apartment over the great furnace, where they are permitted to cool in a greater or less time according to their thickness and bulk. The annealing of steel, or other metallic bodies, consists simply in heating them, and suffering them to cool again either upon the hearth of the furnace, or in any other situation where the heat is moderate, or at least the temperature is not very cold.

ANNOTTO. The pellicles of the seeds of a certain American tree afford the red masses brought into Europe under the name of Annotto, Orlean, and Roucou. The red seeds, cleared from the pods, are steeped in water for seven or eight days, or longer, till the liquors begin to ferment; then strongly stirred, and stamped with wooden paddles and beaters, to promote the separation of the red skins: this process is repeated several times till the seeds are left white. The liquor passed through close cane sieves is pretty thick, of a deep red colour, and very ill smell: in boiling it throws up its colouring matter to the surface in form of scum, which is afterwards boiled down by itself to a due consistence, and made up while soft into balls.

The annotto commonly met with among us is moderately hard, of a brown colour on the outside, and a dull red within. It is difficultly acted upon by water, and tinges the liquor only of a pale brownish yellow colour. In rectified spirit of wine it very readily dissolves, and communicates a high orange or yellowish red. Hence it is used as an ingredient in varnishes, for giving more or less of an orange cast to the simple yellows. Alkaline salt renders it perfectly soluble in boiling water, without altering its colour: wool or silk boiled in the solution acquire a deep but not very durable orange dye. Its colour is not changed by alum or by acids, any more than by alkalis; but when imbibed in cloth, it is discharged by soap, and destroyed by exposure to the air.

Labat informs us, that the Indians prepare an annotto greatly superior to that which is brought to us, of a bright shining red colour, almost equal to carmine; that for this purpose, instead of steeping and fermenting the seeds in water, they rub them with the hands, previously dipped in oil, till the pellicles come off and are reduced into a clean paste, which is scraped off from the hands with a knife, and laid on a clean leaf in the shade to dry. De Laet, in his notes on Margrave's Natural

History of Brazil, mentions also two kinds of annotto; one of a permanent crimson colour (Coccineus), used as a fucus; and another, which gives a colour inclining more to that of saffron. This last, which is our annotto, he supposes to be a mixture of the first sort with certain resinous matters, and with the juice of the roots of the tree.—Ximenes relates, that annotto with urine stains linen of such a permanent colour that is never to be washed out. Perhaps the first sort is meant. Our annotto boiled in urine imparted to linen a deep yellowish red; the stained linen, hung out in the air in summer, in seven or eight days lost all its colour, and became white again*.

ANTIMONY. The word antimony is always used in commerce to denote a metallic ore, consisting of sulphur combined with the semi-metal which is usually called regulus of antimony. But as it appears proper and convenient that the metallic substance itself should be distinguished by a simple term, instead of deriving its name from one of its ores, many chemical writers use the word antimony to denote the metallic substance or regulus, and in this acceptance it is used in the present article.

Antimony is of a silvery white colour, very brittle, and of a plated or scaly texture. Its specific gravity is moderate. Soon after ignition it melts, and by a continuance of the heat it becomes calcined, and rises in white fumes, which may afterwards be volatilized a second time, or fused into a hyacinthine glass, according to the management of the heat: they are called argentine flowers of regulus of antimony. In closed vessels, the regulus rises totally without decomposition. This metallic substance is not subject to rust by exposure to air, though its surface becomes tarnished by that means. Its calces are soluble in water; and in that respect they resemble the calx of arsenic, probably by an approach towards the acid state.

Vitriolic acid, boiled upon the regulus of antimony, calcines the greater part, so as to render it insoluble, the acid being at the same time decomposed. Much vitriolic acid air escapes, and towards the end a small quantity of sulphur is sublimed. By washing the residue in water, a vitriolic salt of antimony is separated from the calx, which does not crystallize.

Nitrous acid very readily attacks antimony in the cold. Most part of the metal is calcined by this action; but a portion is dissolved, and affords deliquescent crystals, decomposable by heat. The calx of antimony formed by this acid is very white, and difficult of reduction.

Continued digestion is required for the solution of regulus of antimony in the marine acid. A considerable quantity is, however, at length dissolved, which affords very deliquescent crystals. This salt melts by the application of heat, and is decomposed by distilled water, in the same manner as the butter of antimony, from which it does not much differ.

Dephlogisticated or aerated marine acid dissolves the regulus of antimony with great facility.

Aqua regia, composed of seven parts nitrous and one marine acid, dissolves it very readily, but lets fall a portion of white calx as it cools. The solvent power of either of the three ancient mineral acids on this semi-metal appears to be increased by mixture with any one of the others.

Earthy substances do not act on the regulus of antimony in the dry way. Its calx however enters readily into the composition of glass, to which it imparts more or less of an hyacinthine colour. When fused with vitriolated tartar it converts it partly

* Lewis on Neumann.

into hepar or liver of sulphur, which dissolves a portion of the calx of antimony; that is to say, the vital air of the acid calcines the regulus of antimony, while part of the acid becomes converted into sulphur, either simply by the loss of its vital air, or else by that loss, together with the acquisition of phlogiston from the regulus.

Nitre detonates very readily with the regulus of antimony; when equal parts of these substances are projected into a red hot crucible, the residue of calx and alkali is known by the name of diaphoretic antimony. When the saline part is washed out by hot water, the residue is called washed diaphoretic antimony. The water used in the washing contains a portion of the calx suspended by the alkali. This may be precipitated by the addition of an acid, and has been distinguished by the name of ceruse of antimony.

When regulus of antimony is pulverized, and accurately mixed with about twice its weight of corrosive sublimate, a mutual action takes place with the production of heat; and if the mixture be distilled with a gentle fire, a thick fluid comes over, which congeals in the receiver, or in the neck of the retort, and is called butter of antimony. The residue consists of revived mercury, and some regulus and calx of antimony. In this experiment, the dephlogisticated marine acid combines with the antimony, while the mercury is revived, as may be easily explained on either of the two theories of chemistry. If the combination of regulus of antimony and sulphur be used instead of the regulus itself, the mercury will be obtained in the form of cinabar, at a much greater heat than is required to sublime the butter of antimony.

When butter of antimony is thrown into pure water, an abundant white precipitate or calx falls down, which is a violent emetic, and is known by the name of powder of algaroth.

Nitrous acid dissolves the butter of antimony. The solution, which does not appear to differ greatly from the solution of the regulus in aqua regia, soon deposits a portion of calx. When an equal weight of nitrous acid has been three times distilled to dryness from butter of antimony, the residue, after ignition, is called bezoar mineral, and seems to be little more than a calx of the metal.

Sulphur combines very readily with the regulus of antimony, and forms a substance differing in no respect from the mineral or ore to which the name of antimony is exclusively appropriated. One part of sulphur completely mineralizes four of the regulus.

Liver of sulphur dissolves the regulus of antimony, and affords an orange-coloured precipitate upon the addition of an acid.

Antimony, or the regulus combined with sulphur, was a favourite object of research in the experiments of the alchemists; in consequence of which its properties are much better known than those of the pure regulus. If this substance be heated, it melts, and a considerable portion of the sulphur flies off, at the same time that the regulus becomes calcined, and rises in white vapours. A gentler heat, less than is necessary to fuse it, converts it into a grey calx; this calx contains a portion of sulphur. If it be urged by a stronger heat, it melts into the form of glass, which is more or less transparent, according to the degree of calcination of the metal and the dissipation of the sulphur. When it contains much sulphur, the glass is fusible, opaque, and of a dark red colour; whence it has been called liver of antimony.

When acids are applied to crude antimony, they dissolve the regulus, and leave the sulphur. The nitrous acid is best adapted to this solution.

Diaphoretic antimony is most commonly and advantageously prepared by detonating the crude antimony with nitre instead of the regulus; the only difference being, that

that more nitre is required for the detonation, and that the residue contains vitriolated tartar as well as alkali and calx.

There are several preparations, consisting of combinations of antimony with an alkali, in which the proportions of the ingredients and the state of the calx are very different, according to the nature and management of the processes. Many of these have been highly praised in medicine, at the same time that they have been as strongly exclaimed against for their ill effects. Both these assertions appear to have been well-founded. It is sufficiently proved, that antimonial medicines have produced the happiest effects, and are justly entitled to be considered as very powerful remedies; but, on the other hand, it is equally certain that their great efficacy must have required greater attention in their first exhibition than perhaps may have been paid; and the complicated nature of many of the processes must have rendered it very difficult to produce substances possessing exactly the same properties, or proportion of component parts, at all times.

If antimony be treated with a fixed alkali, either by fusion and subsequent solution in boiling water, or by simple ebullition, a precipitate is afforded by cooling, which is called kermes mineral, formerly used in medicine. It is thought to consist of the calx of antimony in combination with a portion of sulphur; but its component parts have not been accurately determined, and its properties differ according to the various methods used in preparing it.

The antimonial preparations most commonly used at present are, antimonial wine, and emetic tartar. These, like every other preparation of this semi-metal, are prepared in a variety of ways. The wine may be had by infusing pulverized glass of antimony in Spanish white wine for some days, and then filtering the clear fluid through paper. A very minute portion of the calx is taken up; and this is greater or less, according as the wine is more or less acid; and perhaps according to the temperature of the weather at the time of administering it. On this account it is found necessary to give this medicine cautiously, and by small portions at a time, when it is intended that it shall act as an emetic. The emetic or antimoniated tartar of the London college is thus prepared:—Take of crude antimony and nitre equal parts, separately reduced to powder, mix them, and inject them into a crucible heated to whiteness, that the mixture may melt after deflagration; pour it out, and reserve the yellow mass beneath the scoræ, under the name of crocus of antimony; reduce this to a very subtle powder; boil it in water, and wash the powder repeatedly in warm water till it becomes perfectly insipid; then take equal parts, by weight, of the washed crocus of antimony and of crystals of tartar, and boil them together in three pints of water for every pound of the mixture, during half an hour; filter the liquor, and after due evaporation set it by to crystallize.—This is the antimoniated tartar. It is a triple salt, consisting of the acid of tartar, united to vegetable alkali, and antimony partially calcined, and is considered as a safe medicine, whose properties and effects are more constant and milder than most other antimonial remedies.

It has not been clearly determined on what circumstances the medical effects of antimony depend. The saline preparations of mercury and other metals are supposed to derive their causticity from their tendency to become reduced to the metallic state; in consequence of which they corrode and decompose other combustible substances: but whether this be the case with antimony is doubtful. It appears necessary, however, that antimony should be in the saline state, in order that it may act upon the animal system. When the regulus is made into those small

balls or pills, which, on account of the little change they undergo in passing through the human body, have been called perpetual pills, its purgative action is more or less violent according to the quantity of acid it meets with; and, in the preparations of this semi-metal, their effects seem likewise to be governed by the same circumstance joined to their respective degrees of solubility. The nearly pure and insoluble calx, produced by detonation with a large proportion of nitre, is almost ineffectual; whereas the more soluble calces or combinations are more or less active, according to their respective natures. Hence it appears to follow, that the simplest saline combinations are the most likely to produce effects constantly similar; and that most of the calces and combinations, so highly extolled in the earlier age of chemistry, are attended with dangerous uncertainty in their operation.

Antimony combines with most other metallic substances, and produces mixtures whose properties have been attended to under their respective titles.

Antimony is found either native, in masses of the regulus, composed of shining irregular plates; or calciform, in white crystallized filaments; or combined with sulphur, in the dark blueish or grey friable mineral called antimony, consisting most commonly of brilliant filaments disposed parallel to each other; or, lastly, combined with sulphur and arsenic, in an ore which greatly resembles the foregoing, except that it is of a red or reddish colour.

Native regulus of antimony, or its calx, may be assayed by nitrous acid, which dissolves whatever arsenic it may contain, and only calcines the antimony. The sulphureous antimonial ores are most conveniently analyzed by aqua regia, which takes up the calx, and leaves the sulphur, which may be separated by filtration. The remaining solvent may be examined with the usual precipitants. In the dry way, antimony is separated from its stony parts by fusion in a moderate heat, nearly in the same manner as bismuth, and may be reduced by slowly roasting it, till it becomes converted into a grey calx, which may be briskly fused with twice its weight of black flux.

Antimony and its regulus are chiefly used in medicine, and in some metallic alloys, such as that used for printers' types, small shot, &c.

ANTS. *See* ACID OF ANTS.

APPARATUS. As the whole of the practical part of chemistry consists in placing bodies in contact with each other, so that they may exert their respective attractions or powers of combination without intermixture or disturbance of other bodies not intended to enter the proposed experiments, and also in raising or lowering the temperature of such bodies under examination, it is evident that the degree of success attending these researches must greatly depend upon the vessels or apparatus made use of; and likewise that a great part of the terms in chemistry will be either descriptive of the apparatus, or of the operations performed with them. For this last reason, we shall here speak of the processes in a cursory way, at the same time that we describe the apparatus.

Most operations that require an increase of temperature are performed by the communication of heat from bodies in combustion. But in several operations with bodies in the pneumatical way, the solar focus of a convex lens is used. The processes which are performed by the simple application of heat are the following.

Roasting. This consists in exposing mineral bodies to the heat of an open fire, for the purpose of dissipating their volatile contents.

Calcination is performed by exposing bodies, in an open vessel, to strong heat, till no farther change can be produced in them. The body which remains and with-

withstands the fire is called a calx. Both these terms are more particularly applied to metals. Such bodies as are very little changed by heat are called refractory.

Fusion consists in heating bodies in proper vessels till they become fluid. It is chiefly used for the purpose of uniting smaller bodies into one large mass, and casting them into moulds of any desired figure. The facility with which metals may be united in this way, after they have been divided, is probably the circumstance that induced mankind to use them as the mediums of exchange, or signs of value of all other commodities.

Digestion consists in keeping bodies for a considerable time immersed in a fluid, at a higher temperature than that of the atmosphere, in order that combinations may take place, which could not else have been effected.

Cementation is a process wherein solid bodies, one or more of them being pulverized, are exposed to heat in closed vessels, with the intention that the more volatile parts of the one body may unite with the fixed part of the other.

Evaporation consists in the dissipating of fluids by heat.

Concentration consists in increasing the proportion of saline matter in any watery fluid, either by evaporating part of the water, or by causing it to freeze, and taking away the ice.

When evaporation is performed in vessels either perfectly or nearly closed, so that the volatile parts, which are raised in one part of the apparatus, may be received and condensed in the other parts, the process is called distillation.

Rectification is a subsequent distillation of the product which comes over.

In the distillation of such bodies as are solid, in the usual temperature of the atmosphere, the vapours are scarcely condensed before they become solid again. In this case, the process is called sublimation, and the condensed vapours, which usually have a powdery form, are called flowers. Such are the flowers of brimstone, of benjamin, of zinc, &c. Solid products obtained in this way are called sublimate.

Some of these operations may be performed by a common culinary fire, and indeed most of them may, when the quantities of matter are small, which is usually the case in philosophical experiments. In the arts, where every process requires to be repeatedly carried on in the large way, a variety of furnaces have been contrived to suit the various intentions of the operators. But experimental enquiries demand the occasional exertion of every branch of chemical operation; for which reason, the furnaces and apparatus ought to be constructed on as general principles as possible.

The vessels used in chemistry are, fig. 1, crucibles or pots, made either of earth, black lead, forged iron, or platina. They are used for roasting, calcination, and fusion.

Fig. 2. Cucurbits, matrasses, or bodies, which are glass, earthen, or metallic vessels, usually of the shape of an egg, and open at top. They serve the purposes of digestion, evaporation, &c.

Fig. 3. Retorts are globular vessels of earthen ware, glass, or metal, with a neck bended on one side. Some retorts have another neck or opening at their upper part, through which they may be charged, and the opening may be afterwards closed with a stopper. These are called tubulated retorts.

Fig. 4. Receivers are vessels, usually of glass, of a spherical form, with a straight neck, into which the neck of the retort is usually inserted. When any proper sub-

stance is put into a retort, and heated, its volatile parts pass over into the receiver, where they are condensed.

Fig. 5. The alembic is used for distillation, when the products are too volatile to admit of the use of the last-mentioned apparatus. The alembic consists of a body A, to which is adapted a head B. The head is of a conical figure, and has its external circumference or base depressed lower than its neck, so that the vapours which rise, and are condensed against its sides, run down into the circular channel formed by its depressed part, from whence they are conveyed by the nose or beak C, into the receiver D. This instrument is less simple than the retort, which certainly may be used for the most volatile products, if care be taken to apply a gentle heat on such occasions. But the alembic has its conveniences. In particular, the residues of distillations may be easily cleared out of the body A; and in experiments of sublimation, the head is very convenient to receive the dry products, while the more volatile and elastic parts pass over into the receiver.

Fig. 6. Is the drawing of an alembic commonly made in metal. The head is contained in a vessel of cold water, to accelerate the condensation; a method which is not so rational as that of cooling the receiver, because the coldness of the head in the former case causes much of the vapour to fall again into the body.

Fig. 7. Represents the large stills used in the distillation of ardent spirits. Instead of using a refrigeratory or receiver, the spirit is made to pass through a spiral pipe called the worm, which is immersed in a tub of cold water. During its passage it is condensed, and comes out at the lower extremity, E, of the pipe, in a fluid form.

The best construction of a furnace has not been well ascertained from experience. There are facts which shew that a fire made on a grate near the bottom of a chimney, of equal width throughout, and open both above and below, will produce a more intense heat than any other furnace. What may be the limits for the height of the chimney is not ascertained from any precise trials; but thirty times its diameter would not probably be too high. It seems to be a disadvantage to contract the diameter of a chimney, so as to make it smaller than that of the fire-place, when no other air is to go up the chimney than what has passed through the fire; and there is no prospect of advantage to be derived from widening it.

Fig. 8. Exhibits the common small furnace for melting. A is the ash-hole, where the air enters. C is the fire-place, containing a covered crucible-stand on a support of baked earth, which rests on the grate. D is the passage into E, the chimney. At D is a shallow crucible called a cupel, placed in the current of the flame, and at F is an earthen or stone cover, to be occasionally taken off for the purpose of supplying the fire with fuel.

Fig. 9. Is the reverberatory furnace. A is the fire-place, B the dome and chimney, which is moveable. It serves to reflect the flames, and causes them to surround the vessel C, which is by that means more strongly heated than otherwise.

Charcoal is the material most commonly used in furnaces. It produces an intense heat without smoke, but it is consumed very fast. Coke or charred pit coal produces a very strong and lasting heat. Neither of these produce a strong heat at a distance from the fire. Where the action of flame is required, wood or coal must be burned. Several inconveniences attend the use of coal, as its fuliginous fumes, and its aptitude to stop the passage of air by becoming fused. It is used however in the reverberatory furnaces of glass-houses, and is the best material where vessels are to be supplied with a great quantity of heat at no great intensity, such as in distilleries, &c.

In many operations, where a moderate and regular heat is required, it is advantageous to use a bath, or to coat the vessel intended to be heated. A chemical bath is usually made by putting a quantity of water, sand, or other fluid, or pulverulent substance, into a metallic vessel or pot, and immersing the distilling vessel in it. When the water or sand is once heated, it prevents the sudden changes in the intensity of the fire from affecting the vessel that contains the matter under examination. Chemical baths are made with water, sand, iron filings, mercury, and with the fusible composition of eight parts bismuth, five lead, and three tin, which becomes fluid with a less heat than that of boiling water.

Coating is chiefly intended to prevent glass vessels from cracking by the sudden variations of heat; and serves likewise to render them capable of preserving their figure in higher degrees of heat than they could sustain without it. The materials are clay and fine sand, well worked together into a paste, and with the addition of some hair, such as the bricklayers use. This is laid upon the vessel in successive thin coatings.

The joints or closures of vessels are made tight by compositions called lutes. The clay and sand used for coating makes a very good lute. In the distillation of substances which are not corrosive, it is found convenient to close the junctures with paper or linen pasted on. Wet strips of bladder may also be used in these cases. Slaked lime and the whites of eggs form a good lute, which dries and becomes firm; but the composition called fat lute is used when the vapours are of a corrosive and volatile nature. This is composed of clay, first made very dry and pulverized, and then beat together into a paste with linseed oil, which has been boiled upon litharge, and is known in the shops by the name of drying oil. Fat lute does not harden, but requires to be secured on its place by strips of linen dipped in the lute made of lime and whites of eggs.

The flame of a lamp, with many small wicks, may be used in distillations that require a low heat.

An ingenious student in chemistry, when he has familiarized himself with the first principles, will soon perceive that there are few philosophical enquiries, if any, that require a large apparatus of furnaces or vessels. A tobacco-pipe is a very useful crucible, in which a great number of operations may be performed in a common fire, especially if urged with a pair of good double bellows. An earthen pot, or iron ladle, will contain a sand-bath; and apothecaries phials, or Florence flasks, serve very well for matrasses. Chafing dishes, or small iron stoves, may be applied to serve many useful purposes. And the blow-pipe and spirit-lamp, with a set of small retorts and receivers, may be adapted to the performance of almost every part of experimental chemistry.

The black-lead pots are very convenient for constructing a variety of moveable furnaces. They may be cut without difficulty by a saw whose teeth are set wide, and very easily admit of being scraped, drilled, or ground with sand, to give them the requisite figure. In Dr. Lewis's construction, from whom the four following figures are taken, the pots which are intended to be applied to each other are ground flat upon a stone, with a little sand, the holes are sawed with the common compass-saw of the carpenters, and are made a little narrower externally than internally, by which means it is easy to fit them with stoppers made out of the broken pieces that may be bought where the pieces are sold. Three or four hoops of copper-wire, about the thickness of a crow-quill, and first softened by heating it red hot, are fastened round the pots in the most convenient places, to render them more durable by keeping their

their parts together, after they may have been cracked. A thin copper hoop serves to secure the place of junction of two pots.

Fig. 10. Represents a furnace for open fire formed by one pot. The lower square aperture is the door of the ash-pit, and the upper one the door of the fire-place, which in the intentions this furnace is designed for is kept shut. The charcoal is put in at the top, and supplied with air by one or more of the lower apertures, and the intensity of the fire may in some measure be regulated by more or less closing of the apertures. If an iron pot, a ladle, or an old frying-pan, containing sand, be put over this fire on three iron supporters, so as to leave room for the escape of the burned air from the fire, a bath will be formed, in which digestions, distillations, and other chemical operations, may be performed. The round hole in the bottom serves to insert the nozzle of a pair of bellows, which, when the other apertures are stopped, converts it into a blast furnace.

Fig. 11. Is a wind furnace, formed by two pots applied mouth to mouth. An iron chimney, composed of pieces by which its length may be regulated so as to increase the draft at pleasure, is put on the top. The crucible containing the subject matters is placed upon a circular piece of brick laid upon the grate, which prevents the cold air from immediately striking the crucible and endangering the breaking it. The charcoal is put through the fire-place door, or larger aperture of the dome, or upper pot, which should always be closed immediately after each supply of fuel. The two opposite holes in the upper part of the dome afford the convenience of passing an iron rod through, for safely and commodiously lifting it when intensely heated.

Fig. 12. Is a furnace consisting of two pots, separated by an iron hoop, in which an opening or door is cut. It serves for a reverberatory furnace for distilling with retorts of earthen-ware or coated glass. The bottom of the distilling vessel rests on two bars laid across within the lower pot. If the grate of this furnace be occasionally changed for a larger, which may be placed near the edge of the lower pot, a muffle, or small earthen oven, may be placed in the midst of the fire with its mouth opposite the hole in the iron hoop. In this may be performed all processes that require the admission of air and frequent inspection, such as assays, enamelling, &c.

Fig. 13. Is an improved blast furnace. The pot which contains the fuel for this purpose has a number of holes bored at small distances, in spiral lines, all over it, from the bottom up to such an height as it is designed the fuel shall reach. The crucible is placed upon a proper support in the bottom, and the holes are made not in a perpendicular direction to it, but oblique, that the streams of air forced in through them may but just touch it; by this means the crucible is in no danger of being cracked by the blast, and the impelled heat plays in a kind of spiral upon its surface. The lower pot receives this perforated pot to such a depth that all its holes hang in the cavity, which cavity having no other outlet than the aperture for the bellows, the air blown in through this aperture necessarily distributes itself through the perforations of the inner pot. Both pots may be of the largest size, the external narrow part of the inner falling into the wide mouth of the outer. It wants no addition to its height; but, on the contrary, will be more commodious in regard to the inspection and taking out of the crucible, if all the part above where the fuel reaches be sawed away. The most convenient cover for it is an iron plate with a round hole in the middle, and a handle projecting at one side for lifting it. (Letter A.)

The force of the fire being thus in a great measure concentrated upon the crucible in the middle of the fuel, the crucible is heated expeditiously, and with a little quantity

quantity of fuel, to a very intense degree, while the exterior parts of the furnace are of no great heat, and permit the operator to approach without incommoding him.

Every effect of the most violent heat of furnaces may be produced by the flame of a candle or lamp, urged upon a small particle of any substance, by the blow-pipe. This instrument is sold by the ironmongers, and consists merely of a brass pipe about one eighth of an inch diameter at one end, and the other tapering to a much less size, with a very small perforation for the wind to escape. The smaller end is bended on one side. For philosophical or other nice purposes the blow-pipe is provided with a bowl or enlargement, B (fig. 14), in which the vapours of the breath are condensed and detained, and also with three or four small nozles, with different apertures, to be slipped on the smaller extremity. These are of use when larger or smaller flames are to be occasionally used, because a larger flame requires a large aperture, in order that the air may effectually urge it upon the matter under examination.

There is an artifice in the blowing through this pipe, which is more difficult to describe than to acquire. The effect intended to be produced is a continual stream of air for many minutes, if necessary, without ceasing. This is done by applying the tongue to the roof of the mouth, so as to interrupt the communication between the mouth and the passage of the nostrils; by which means the operator is at liberty to breathe through the nostrils, at the same time that by the muscles of the lips he forces a continual stream of air from the anterior part of the mouth through the blow-pipe. When the mouth begins to be empty, it is replenished by the lungs in an instant, while the tongue is withdrawn from the roof of the mouth, and replaced again in the same manner as in pronouncing the monosyllable tut. In this way the stream may be continued for a long time without any fatigue, if the flame be not urged too impetuously, and even in this case no other fatigue is felt than that of the muscles of the lips.

A wax candle of a moderate size, but thicker wick than they are usually made with, is the most convenient for occasional experiments; but a tallow candle will do very well. The candle should be snuffed rather short, and the wick turned on one side towards the object, so that a part of it should lie horizontally. The stream of air must be blown along this horizontal part, as near as may be without striking the wick. If the flame be ragged and irregular, it is a proof that the hole is not round or smooth; and if the flame have a cavity through it, the aperture of the pipe is too large. When the hole is of a proper figure and duly proportioned, the flame consists of a neat luminous blue cone, surrounded by another flame of a more faint and indistinct appearance. The strongest heat is at the point of the inner flame.

The body intended to be acted on by the blow-pipe ought not to exceed the size of a pepper-corn. It may be laid upon a piece of close-grained well-burned charcoal, unless it be of such a nature as to sink into the pores of that substance, or to have its properties affected by its inflammable quality. Such bodies may be placed in a small spoon made of pure gold or silver, or platina.

Many advantages may be derived from the use of this simple and valuable instrument. Its smallness, which renders it suitable to the pocket, is no inconsiderable recommendation. The most expensive materials, and the minutest specimens of bodies, may be used in these experiments, and the whole process, instead of being carried on in an opaque vessel, is under the eye of the observer from beginning to end. It is true, that very little can be determined in this way concerning the quantities of products; but, in most cases, a knowledge of the contents of any substance

stance is a great acquisition, which is thus obtained in a very short time, and will at all events serve to shew the best and least expensive way of conducting processes with the same matters in the larger way.

The blow-pipe has deservedly of late years been considered as an essential instrument in a chemical laboratory, and several attempts have been made to facilitate its use by the addition of bellows, or some other equivalent instruments. These are doubtless very convenient, though they render it less portable for mineralogical researches. It will not, here, be necessary to enter into any description of a pair of double bellows fixed under a table, and communicating with a blow-pipe which passes through the table. Smaller bellows, of a portable size for the pocket, have been made for the same purpose. The ingenious chemist will find no great difficulty in adapting a bladder to the blow-pipe, which, under the pressure of a board, may produce a constant stream of air, and may be replenished, as it becomes empty, by blowing into it with bellows, or the mouth, at another aperture furnished with a valve opening inwards.

The chief advantage these contrivances have over the common blow-pipe is, that they may be filled with vital or dephlogisticated air, which increases the activity of combustion to an astonishing degree. For the various habitudes of bodies when examined by the blow-pipe, *see* BLOW-PIPE.

Little need be said concerning the manner of making experiments with fluid bodies in the common temperature of the atmosphere. Basons, cups, phials, matraffes, and other similar vessels, form the whole apparatus required for the purpose of containing the matters intended to be put together, and no other precaution or instruction is required than to use a vessel of such materials as shall not be corroded or acted upon by its contents, and of sufficient capacity to admit of any sudden expansion or frothing of the fluid, if expected. This vessel must be placed in a current of air, if noxious fumes arise, in order that these may be blown from the operation.

The method of making experiments with permanently elastic fluids, or air, though simple, is not so obvious. We live immersed in an atmosphere not greatly differing in density from these fluids, which are not for that reason sufficiently ponderous to be detained in open vessels by their weight. Their remarkable levity, however, affords a method of confining them by means of other denser fluids. Dr. Priestley, whose labours have so far exceeded those of his predecessors and contemporaries, both in extent and importance, that he may with justice be styled the father of this important branch of natural philosophy, uses the following apparatus.

Fig. 15. A represents a wooden vessel or tub; K, K, K, is a shelf fixed in the tub. When this apparatus is used, the tub is to be filled with water to such an height as to rise about one inch above the upper surface of the shelf. B, G, F, are glass jars inverted with their mouths downwards, which rest upon the shelf. If these, or any other vessels open only at one end, be plunged under the water, and inverted after they are filled, they will remain full, notwithstanding their being raised out of the water, provided their mouths be kept immersed: for in this case, the water is sustained by the pressure of the atmosphere, in the same manner as the mercury in the barometer. It may without difficulty be imagined, that if common air, or any other fluid resembling common air in lightness and elasticity, be suffered to enter these vessels, it will rise to the upper part, and the surface of the water will subside. If a bottle, a cup, or any other vessel, in that state which is usually called empty, though really full of air, be plunged into the water with its mouth downwards, scarce any water will enter, because its entrance is opposed by the elasticity of the included air;

air; but if the vessel be turned up, it immediately fills, and the air rises in one or more bubbles to the surface. Suppose this operation to be performed under one of the jars which are filled with water, the air will ascend as before; but, instead of escaping, it will be detained in the upper part of the jar. In this manner, therefore, we see that air may be emptied out of one vessel into another by an inverted pouring, in which the air is made to ascend from the lower to the upper vessel, in which the experiments are performed, by the action of the weightier fluid, exactly similar to the common pouring of denser fluids, detained in the bottoms of open vessels, by the simple action of gravity. When the receiving vessel has a narrow neck, the air may be poured through a glass funnel, H.

C (fig. 15) is a glass body or bottle, whose bottom is blown very thin, that it may support the heat of a candle suddenly applied, without cracking. In its neck is fitted, by grinding, a tube D, curved neatly in the form of the letter S. This kind of vessel is very useful in various chemical operations, for which it will be convenient to have them of several sizes. In the figure, the body C is represented as containing a fluid, in the act of combining with a substance that gives out air, which passes through the tube into the jar B, under whose mouth the other extremity of the tube is placed. At E is a small retort of glass or earthen-ware, whose neck being plunged in the water, beneath the jar F, is supposed to emit the elastic fluid, extricated from the contents of the retort, which is received in the jar.

When any thing, as a gallipot, is to be supported at a considerable height within a jar, it is convenient to have such wire stands as are represented fig. 16. These answer better than any other, because they take up but little room, and are easily bended to any figure or height.

In order to expel air from solid substances by means of heat, a gun-barrel, with the touch-hole screwed up and rivetted, may be used instead of an iron retort. The subject may be placed in the chamber of the barrel, and the rest of the bore may be filled with dry sand, that has been well burned, to expel whatever air it might have contained. The stem of a tobacco-pipe, or a small glass tube, being luted in the orifice of the barrel, the other extremity must be put into the fire, that the heat may expel the air from its contents. This air will of course pass through the tube, and may be received under an inverted vessel, in the usual manner.

But the most accurate method of procuring air from several substances by means of heat, is to put them, if they will bear it, into phials full of quicksilver, with the mouths inverted in the same, and then throw the focus of a burning lens or mirror upon them. For this purpose, their bottoms should be round and very thin, that they may not be liable to fly with the sudden application of heat. The body C answers this purpose very well.

Many kinds of air combine with water, and therefore require to be treated in an apparatus in which quicksilver is made use of. This fluid being very ponderous, and of considerable price, it is an object of convenience as well as economy, that the trough and vessels should be smaller than when water is used.

When trial is to be made of any kind of air, whether it be fit for maintaining combustion, the air may be put in a long narrow glass vessel, whose mouth being carefully covered, may be turned upward. A bit of wax candle being then fastened to the end of a wire, which is bended so that the flame of the candle may be uppermost, is to be let down into the vessel, which must be kept covered till the instant of plunging the lighted candle in the air.

Where the change of dimensions, which follows from the mixture of several kinds of air, is to be ascertained, a graduated narrow cylindrical vessel may be made use

of. The graduations may be made by pouring in successive equal measures of water into this vessel, and marking its surface at each addition. The measure may be afterwards used for the different kinds of air, and the change of dimensions will be shewn by rise or fall of the mercury or water in the graduated vessel. The purity of common air being determinable by the diminution produced by the addition of nitrous air, these tubes have been called eudiometer tubes. There are instruments called eudiometers, which consist of an assemblage of parts adapted to the due mixture of these airs, and the accurate measurement of the change of bulk they undergo.

Some substances, more especially powders, cannot conveniently be put in a phial, or passed through a fluid. When air is to be extricated from, or added to these, there is no better method than to place them on a stand under the receiver of the air-pump, and exhaust the common air instead of excluding it by water or mercury. This process requires a good air-pump and careful management, otherwise the common air will not be well excluded.

It is frequently an interesting object to pass the electric spark through different kinds of air, either alone or mixed together. In this case a metallic wire may be fastened in the upper end of a tube, and the sparks or shock may be passed through this wire to the mercury or water used to confine the air. If there be reason to apprehend that an expansion in the air may remove the mercury or water beyond the striking distance, another wire may be thrust up to receive the electricity, or two wires may be cemented into opposite holes in the sides of an hermetically sealed tube. Holes may be made in glass, for this and other chemical uses, by a drill of copper or soft iron, with emery and water; and where this instrument is wanting, a small round file with water will cut a notch in small vessels, such as phials or tubes, though with some danger of breaking them. In some electrical experiments of the kind here mentioned, there is reason to expect a fallacious result from the wires being burned by the explosion or spark. For this reason, the electricity may be made to pass through the legs of a syphon, containing the air which is under consideration in the upper part of its curvature. One of the vessels, in which the legs of the syphon rest, must therefore be insulated; and if any watery fluid be used to confine the air, it is generally supposed that no combustion takes place.

The process of impregnating water with any aerial fluid it will combine with, does not require any particular apparatus, but may be performed with such utensils as are every where to be met with. The most usual operation of this kind, is that of impregnating water with fixed air, which may be done in the following manner. The quart bottle C, fig. 17, is filled with water, and inverted into the basin F, which likewise contains a little water. The inversion may be easily managed, without any of the contents of the bottle escaping, if its orifice be covered with a card, to be withdrawn after the immersion. A is a half pint phial, into which broken pieces of marble or chalk are put; and upon them is poured as much water, rendered very acid by a mixture of oil of vitriol, as may fill the bottle two-thirds. B is a bladder, whose neck is tied fast round a perforated cork of a tapering figure. After the effervescence of the chalk and the acid has begun, the cork is to be thrust into the neck of the phial A; the bladder being previously emptied by pressure. Fixed air will escape from the chalk, and inflate the bladder. When this last is full, it must be disengaged from the bottle, and the bended tube E must be thrust into the orifice of its cork. The aperture of the tube being then placed beneath the mouth of the bottle C, it is easy to discharge the aerial contents of the bladder by pressure into this last. Agitation of the bottle C, without withdrawing its neck out of the water, increases the contact of the air and water, by dividing them into small parts, and by
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that means causes the absorption to take place in a few seconds. Two or three repetitions of the process impregnates the water so fully, that it will absorb no more in this way. The Pyrmont water is of this kind.

The use of the bladder in this operation is only to prevent any of the fluid contents of the bottle A from passing into the bottle C, which would happen in the violent state of ebullition, if the tube E were to pass directly from the bottle A to C. The manipulation is simpler if the bladder have two holes at its opposite ends, the one containing a cork, constantly kept in the neck of the bottle A, and the other fastened round the tube E, which then remains constantly beneath the mouth of C, and the air is pressed up as occasion may demand. See fig. 18.

When habitual use is made of water impregnated with fixed air, the apparatus of Dr. Nooth is very effectual and convenient. It consists of three glass vessels (fig. 19). The lower vessel C contains the effervescent materials; it has a small orifice at D, stopped with a ground-stopper, at which an additional supply of either acid or water, or chalk, may be occasionally introduced. The middle vessel B is open, both above and below. Its inferior neck is fitted by grinding into the neck H of the lower vessel. In the former is a glass valve, formed by two pieces of tube, and a lens, which is moveable, between them, as represented in fig. 20. This valve opens upwards, and suffers the air to pass; but the water cannot return through the tubes, partly because the orifice is capillary, and partly because the flat lens covers the hole. The middle vessel is furnished with a cock E, to draw off its contents. The upper vessel A is fitted, by grinding, into the upper neck of the middle vessel. Its inferior part consists of a tube that passes almost as low as the centre of the middle vessel. Its upper orifice is closed by a ground stopper F. When this apparatus is to be used, the effervescent materials are put into the lower vessel, the middle vessel is filled with pure water, and put in its place; and the upper vessel is nearly stopped, and likewise put in its place. The consequence is, that the fixed air passing through the valve at H, ascends into the upper part of the middle vessel B, where by its elasticity it re-acts on the water, and forces part up the tube into the vessel A; part of the common air, in this last, being compressed, and the rest escaping by the stopper, which is made of a conical figure, that it may be easily raised. As more fixed air is extricated, more water rises, till at length the water in the middle vessel falls below the lower orifice of the tube. Fixed air then passes through the tube into the upper vessel, and expels more of the common air by raising the stopper. In this situation the water in both vessels being in contact with a body of fixed air, becomes strongly impregnated with that fluid, after a certain time. This effect may be hastened by taking off the middle and upper vessels together, and agitating them.

The valve is the most defective part of this apparatus; for the capillary tube does not admit the air through, unless there be a considerable quantity condensed in the lower vessel; and the condensation has in some instances burst the vessel.

Modern discoveries respecting bodies in the aeriform state have produced several capital improvements in the vessels used for distillation. It was common with the earliest chemists to make a small hole in the upper part of their retorts, that the elastic vapours might escape, which would otherwise have burst the vessels. By this means they lost a very considerable part of their products. Fig. 21 is an apparatus of vessels, in which all the products may be examined. A is a matrafs which communicates with the receiver B, by a tube that reaches very near the bottom of the latter. The upper part of this receiver communicates in the same manner with the second receiver C, by a tube reaching nearly to the bottom of C. In like manner C communicates with D, and from D proceeds a re-curved tube, which may be

inserted beneath an inverted vessel of water or mercury. It is evident, in this apparatus, that whatever volatile matter escapes from the vessel A, by heat or other wise, will either be condensed in B, C, or D; and that the aerial products will pass through the whole set, and through the re-curved tube, into the inverted vessel. These receivers may be more or less numerous according to circumstances, and the volatile products may be condensed in, or made to pass through, water, oil, or any other fluids, placed in either of the receivers. The tubes may be either fitted in with cork and cement, or, which is better but more expensive, by grinding. Small vessels of this kind form a convenient interruption in the re-curved tube, passing from a bottle containing matters that give out air, as they are preferable in closeness and neatness to a bladder.

Fig. 22. Exhibits an improvement in the receiver in distillation by Mr. Woulfe. A is the retort; B an intermediate vessel called an adapter, which is only occasionally used; C the receiver, having two necks, one at D inserted into a bottle, which receives the products which are usually condensed in the receivers, and the other at E, transmits the more volatile or aeriform products into a basin G, containing water, beneath the surface of which the extremity of the neck E is plunged. It is obvious that this apparatus is more particularly useful when the products are such as combine with the fluids in G, and would otherwise escape; and it is hardly necessary to observe, that a bottle, or other convenient vessel, may be substituted instead of the basin G.

It often happens in chemical processes, from the irregularity of the heat, or from other circumstances, that the condensation is more rapid, in proportion to the supply of vapour, at some period of the same operation than at others. Whenever this takes place, the elasticity of the vapours will not be equal to the external pressure of the air; and if any orifice of the vessels which are in other respects closed be plunged in water, or any other fluid, this last will be pressed into the vessels. The remedy for this inconvenience is, to plunge the neck of the vessel to no greater depth in the water, than that the fall of the water in the receiving vessel may leave the orifice open for the admission of air, before the water has risen high enough above the orifice to reach the contents of the vessels. This effect is increased by making the neck large, in proportion to the diameter of the vessel which contains the water. Thus, if the neck E be made large, and the water from the basin G should, by a rapid condensation in C, be forced up the neck, the surface of the water in G will fall so much as to leave the lower orifice of E uncovered, before any considerable rise can take place. The best remedy against absorption, in fig. 21, is to insert a small tube through the cork of the first vessel B, to reach nearly to its bottom. This will admit the outer air on such occasions, and prevent the contents of the exterior bottles from being driven back by the pressure of the atmosphere. This observation applies to all chemical vessels, and is in no case more essential than when the neck of a simple retort is plunged in water contained in a receiver. *See* BALANCE, THERMOMETER, HEAT, DISTILLATION.

APPLES. *See* ACID OF APPLES.

APYROUS. Bodies which sustain the action of a strong heat for a considerable time without change of figure or other properties, have been called apyrous: but the word is seldom used in the art of chemistry; it is synonymous with the word refractory.

AQUA FORTIS. This name is given to a weak, and somewhat impure nitrous acid, commonly used in the arts. It is usually contaminated with a small quantity of marine acid. The artists who use nitrous acid distinguish the common and less pure acid by the name of aqua fortis, and call the more concentrated acid, spirit of

of nitre. This distinction appears to be of some utility, and is therefore not improperly retained by chemical writers. See ACID, NITROUS.

The manufacturers of sope in France and elsewhere call their lixivium or sope-les by the name of strong water; and this name (*eau forte*) being consequently used to denote the caustic alkali in recipes for dying and other processes, has given rise to several mistakes.

AQUA MARINE, or AUGITES. A precious stone of a transparent green, blue colour, fusible by the blow-pipe; it is nearly the same both in form and specific gravity with the Peru emerald, and the chrysolite. Its specific gravity is about 2,72, and its hardness nearly the same as that of quartz.

AQUA REGIA, or REGIS. This acid is compounded of a mixture of the nitrous and marine acids, the bases of which, together with a certain proportion of vital air different from what originally existed in the two acids, become combined in a manner which has not been clearly explained. When one or two parts of pale concentrated nitrous acid are mixed with four of marine acid, an effervescence soon takes place, and dephlogisticated marine acid flies off in the elastic form, at the same time that the mixture becomes of a deep red colour: it has obtained its name from its property of dissolving gold, the royal metal of the alchemists, which is not perceptibly acted upon by either of the acids which compose it.

Aqua regia may be made by adding to nitrous acid any alkaline or earthy salt which contains the marine acid; for the affinity of the nitrous acid to the base being in most cases stronger than the marine, this last is set at liberty, and consequently the mixture, if the salt be not excessive in quantity, so as to engage the whole of the nitrous acid, will contain a certain portion of both acids at liberty. An aqua regia will therefore be produced, which is not essentially impaired with respect to common uses by the portion of neutral salt suspended in it. It is usual to make aqua regia by dissolving sal ammoniac in about four times its weight of strong nitrous acid; but the results of experiments must vary considerably according to the nature and proportions of the ingredients made use of.

The opinions and inferences of chemical writers respecting the nature of this mixed acid, are various. After the discovery of the dephlogisticated marine acid, it was concluded that the nitrous acid performs the same office with respect to the marine as the manganese does; that is, in fact, that it either deprives the marine acid of phlogiston, or affords vital air to combine with it, or answers both these purposes. This general supposition is not however without several difficulties. If the marine acid be enabled to calcine and dissolve gold, because it has been dephlogisticated or aerated by the nitrous, it should follow much more strongly that the nitrous acid itself should dissolve that metal; whereas in fact it does not. And again, it has not been shewn how this dephlogisticated acid, which is so volatile and so sparingly soluble in water, is retained in the solution; not to mention that no component part of the nitrous acid is found to escape during the effervescence, except the vital air which enters into the composition of the gas which flies off. When the two acids are in due proportion, aqua regia must therefore consist of marine acid and nitrous acid, which has an under-proportion of vital air, or is in the most fuming state; or, in other words, it contains the two bases of the acids, together with a less proportion of vital air than they possessed before mixture. But whether these principles combine, and form a compound acid, or in what other order they may be arranged, has not been experimentally determined, though the writings of chemists abound with conjectures upon this subject.

The combinations of earths and alkalis, and even of metals, with aqua regia have
not

not been well examined. It is not known whether two different kinds of salts are formed apart from each other, or whether a triple combination takes place, consisting of two acids united to one base. It appears, however, that in some cases the result is one entire compound, and in others two separate ones. See GOLD, PLATINA, and the other metals.

AQUA SECUNDA. This name is sometimes given to an exceedingly diluted aqua fortis, used in the arts for cleaning the surface of metals, and some other bodies.

AQUA VITÆ. Ardent spirit of the first distillation has been distinguished in commerce by this name. The distillers of malt and molasses spirits call it low wines.

AQUILA ALBA. One of the names given to the combination of marine acid and mercury in that state which is more commonly known by the denomination of mercurius dulcis, or, less properly, calomel.

ARABIC, GUM. This is reckoned the purest of gums, and does not greatly differ from gum Senegal, vulgarly called gum seneca, which is supposed to be the strongest, and is on that account, as well as its greater plenty and cheapness, mostly used by callico printers and other manufacturers. The gums of the plum and the cherry tree have nearly the same qualities as gum arabic. All these substances facilitate the mixture of oils with water, and they are said to suffer a decomposition, or considerable change, by freezing, but of what nature has not been clearly explained.

ARABLE LANDS. It is a problem in chemistry, and by no means one of the least importance to society, to determine what are the requisites which distinguish fruitful lands from such as are less productive. Since vegetable substances evidently imbibe from the earth and surrounding atmosphere, the principles of oils, mucilages, and other peculiar products only found in organized substances, it can scarcely be doubted but that manure, or the remains of other decayed organized substances, renders lands fruitful, by supplying these materials ready formed. It may happen, however, that the putrefactive process in a considerable quantity of manure may be so effective as to overcome the vital powers, or destroy the organization of the plant; and on this account an excess of manure must be hurtful. In those cases wherein vegetation is performed without the presence of any thing which may be called manure, it seems proper, as far as the few and imperfect lights of chemistry can serve to direct us, to ascribe the growing or augmentation of vegetables to the decomposition of water or the air of the atmosphere, rather than to any considerable addition of earthy particles; more especially, as it appears, from good experiments, that the earth in which vegetables grow suffers very little loss of its weight in consequence of their increase. From the indispensable necessity of water in vegetation, it appears that this fluid either supplies the greatest part of the mass of vegetables, or is at least the vehicle or medium by which aerial fluids are condensed and conveyed into the vegetable substance; which leads to a conclusion, that, generally speaking, those earths which are the best adapted to imbibe and retain water, and at the same time admit the access of air, are most fruitful. Sand or small particles of siliceous earth are evidently the least adapted to this purpose. Clays of considerable purity will be too stiff, impenetrable, and adhesive. Chalky or calcareous soils are not only hard and permanent, so as to be with considerable difficulty penetrated by the roots of vegetables, but are little adapted either to imbibe more water than they naturally possess, or to part with that they already have. Little need be said of the ponderous and
magnesian

magnesian earths, as they do not enter in any notable proportion as ingredients in soils.

If we might therefore overlook the presence of saline and combustible matter, which are indeed necessary to fertility, and the latter of which is the cause of the dark colour of mould, our attention would be naturally directed to a mixture of the siliceous, calcareous, and argillaceous earths, that is to say, of sand, chalk or lime, and clay. The first being totally insoluble in water, can scarcely be expected to answer any other purpose than that of mechanically separating the parts of the mafs, or at least of rendering them more easily separable by frost and other atmospherical changes. The calcareous and argillaceous earths form the composition distinguished by the name of marle, and this will vary in its properties according to the nature of its composition; the friability and solubility of the lime in water serving greatly to correct the bad effects of the mere clay, while this on the other hand produces a change of equal advantage in the chalk or lime. It may easily be apprehended that the presence of vitriolic acid or other acidifiable substances, together with the access of air, cannot but produce changes by combination with these two earths, which will be still more considerable, and cannot indeed be followed by any conjectural reasoning, though the little we know of the subject sufficiently evinces the great utility of experiments in this department of chemical enquiry.

ARBOR DIANÆ. All bodies whatever, in their transition from the fluid to the solid state, are disposed to arrange themselves in peculiar symmetrical figures. *See CRYSTALLIZATION.* When one body is precipitated from its solvent by the addition of another, the transition to solidity is usually so quick that the parts have not time to arrange themselves, excepting in such minute masses as constitute the pulverulent form. When silver is dissolved in nitrous acid, and mercury is added, the elective attraction between the mercury and the acid acts with such a degree of slowness, that the silver in certain cases is separated in the form of a tree or shrub, which the earlier chemists in their usual fanciful way called the tree of Diana. In this, as in all precipitations, there are a variety of concomitant circumstances which influence the peculiar form, and, for this reason, one process usually succeeds better than another. Lemery directs, that an ounce of fine silver be dissolved in a sufficient quantity of pure and moderately strong nitrous acid. This solution must then be mixed in a matrass with about twenty ounces of distilled water; and lastly, two ounces of mercury are to be added to the mixture, after which the whole must be suffered to remain at rest. During a space of about forty days, a kind of tree of silver will be formed on the surface of the mercury, with branches greatly resembling a vegetable substance in its ramifications. Macquer affirms that this process succeeds very well, but the following of Homberg is much shorter.

Make an amalgam without heat, of four drams of leaf silver, with two drams of mercury. Dissolve this amalgam in four ounces, or a sufficient quantity of pure nitrous acid of a moderate strength; dilute this solution in about a pound and a half of distilled water, agitate the mixture, and preserve it for use in a glass bottle with a ground stopper. When this preparation is to be used, the quantity of one ounce is put into a phial, and the size of a pea of an amalgam of gold or silver, as soft as butter, is to be added; after which the vessel must be left at rest: soon afterwards, small filaments appear to issue out of the ball of amalgam, which quickly increase, and shoot out branches in the form of shrubs.

In the above experiment of Lemery, the nitrous acid deposits its silver, at the same time that it takes up mercury; and, in consequence of the liquor being so much diluted, the process goes on slowly, and the precipitated silver has time to arrange itself

according to the laws of its crystallization, whether that depend on the polarity of its particles, or on any other property not yet explained. In the process of Homberg, there are two circumstances which appear calculated to forward the process: in the first place, the nitrous acid already contains mercury in solution, which may probably render it more disposed to part with the silver; and in the next place, the mercury is combined with silver or gold in the form of an amalgam. These may, perhaps, facilitate the precipitation of the silver, by presenting a base for it to combine with, which may be more perfectly at repose, because less agitable than the fluid mercury in the former experiment. After all, however, though the general theory of the experiment is not difficult, yet it does not seem easy to point out the effectual cause of the differences between the two results.

ARCANUM CORALLINUM. This name has been given to red precipitate, on which spirit of wine has been two or three times burnt, with an intention of rendering it milder. See PRECIPITATE, RED, or the article MERCURY.

ARCANUM DUPLICATUM. A name formerly given to the combination of vegetable alkali and vitriolic acid, and most commonly called vitriolated tartar.

ARCHIL, ARCHILLA, ROCELLA, ORSEILLE. A whitish moss growing upon rocks in the Canary and Cape Verd islands, which yields a rich purple tincture, fugitive indeed, but extremely beautiful. This weed is imported to us as it is gathered: those who prepare it for the use of the dyer, grind it betwixt stones, so as to thoroughly bruise, but not to reduce it into powder, and then moisten it occasionally with a strong spirit of urine, or urine itself mixed with quicklime: in a few days it acquires a purplish red, and at length a blue colour; in the first state it is called archil, in the latter, lacmus or litmus.

The dyers rarely employ this drug by itself, on account of its dearth and the perishableness of its beauty. The chief use they make of it is for giving a bloom to other colours, as pinks, &c. This is effected by passing the dyed cloth or silk through hot water lightly impregnated with the archil. The bloom thus communicated soon decays upon exposure to the air. Mr. Hellot informs us, that by the addition of a little solution of tin, this drug gives a durable dye; that its colour is at the same time changed towards a scarlet, and that it is the more permanent, in proportion as it recedes the more from its natural colour.

Prepared archil very readily gives out its colour to water, to volatile spirits, and to spirit of wine; it is the substance principally made use of for colouring the spirits of thermometers. As exposure to the air destroys its colour upon cloth, the exclusion of the air produces a like effect in those hermetically sealed tubes, the spirits of large thermometers becoming in the compass of a few years colourless. M. l'Abbé Nollet observes (in the French Memoirs for the year 1742), that the colourless spirit, upon breaking the tube, soon resumes its colour, and this for a number of times successively; that a watery tincture of archil, included in the tubes of thermometers, lost its colour in three days; and that in an open deep vessel, it became colourless at the bottom, while the upper part retained its colour.

A solution of archil, in water, applied on cold marble, stains it of a beautiful violet or purplish blue colour, far more durable than the colour which it communicates to other bodies. M. Du Fay says, he has seen pieces of marble stained with it, which in two years had suffered no sensible change. It sinks deep into the marble, sometimes above an inch, and at the same time spreads upon the surface, unless the edges be bounded by wax or other like substances. It seems to make the marble somewhat more brittle.

Linnaeus informs us, in the Swedish Transactions for the year 1742, that the true archil moss is to be found on the western coasts of England; and suspects that there are several other more common mosses, from which valuable colours might be extracted. A quantity of sea moss having rotted in heaps upon the shore, he observed the liquor in the heaps to look like blood; the sea water, and the sun, and the putrefaction having brought out the colour. M. Kalm, in an Appendix to Linnaeus's Paper in the year 1745, mentions two sorts of mosses actually employed in some parts of Sweden for dying woollen red: one is the lichenoides coralliforme apicibus coccineis of Ray's Synopsis; the other, the lichenoides tartareum, farinaceum, scutellarum umbone fusco of Dillenius. This last is a white substance, like meal clotted together, found on the sides and tops of hills. It is shaved off from the rocks after rain, purified from the stony matters intermixed among it, by washing with water; then dried in the sun, ground in mills, and again washed and dried: it is then put into a vessel with urine, and set by for a month. A little of this tincture added to boiling water makes the dying liquor.—In the same Transactions, for the year 1744, there is an account of another moss, which, prepared with urine, gives a beautiful and durable red or violet dye to wool and silk. This is the lichen foliaceus, umbilicatus subtus lacunefus Linn. Flor. Suec. It grows upon rocks, and is readily distinguished from others of that class, by its looking as if burnt or parched, consisting of leaves as thin as paper, convex all over on the upper side, with corresponding cavities underneath; adhering firmly to the stones by a little root under the leaves, and coming asunder, when dry, as soon as touched. It is gathered after rain, as it then holds best together, and parts easiest from the stone.

In France, a crustaceous moss, growing upon rocks in Auvergne, is prepared with lime and urine, and employed by the dyers as a succedaneum to the Canary archil, to which it is said to be very little inferior: it is called Orseille d'Auvergne, or Perelle. Mr. Hellot relates, that he has met with several other mosses, which, on being prepared in the same manner, acquire the same colour. The most expeditious way, he says, of trying whether any moss will yield an archil or not, is, to moisten a little of it with a mixture of equal parts of spirit of sal ammoniac and strong lime-water, and add a small proportion of crude sal ammoniac. The glass is then to be tied over with a piece of bladder, and set by for three or four days. If the moss is of the proper kind, the little liquor which runs from it upon inclining the vessel, will appear of a deep crimson colour; and this afterwards evaporating, the plant itself acquires the same colour.

Lewis*, from whom this article is taken, tried a good number of the common mosses, both of the crustaceous and foliaceous kind, and not a few of the fungi; as also the herbs chamomile and milfoil, which yield a blue essential oil; and thyme, whose oil becomes blue by digestion with volatile spirits; but have not as yet met with any that yielded a colour like archil. Most of them gave a yellow or reddish brown tincture; and if there was a scarcity of other drugs for these kinds of dyes, some of the mosses might be made to afford not inelegant ones. A few gave a deep red colour to the liquor; but when diluted it shewed a yellowish cast, and when applied on cloth it gave only a yellowish red.

ARDENT SPIRIT. See SPIRIT, ARDENT, or OF WINE.

ARGILLACEOUS EARTH. See EARTHS.

ARMENUS LAPIS. ARMENIAN STONE. This is a soft blue stone, which does not admit of a polish, and consists of calcareous earth, or gypsum, penetra-

* On Neumann, II. 211.

ting with the blue calx of copper. Hence it sometimes effervesces with acids, and sometimes not. It is too soft to give fire with steel, and loses its colour when heated.

AROMA. The principle of smell in vegetables.

AROMATICS. Plants which possess a peculiar and remarkable smell are called aromatics. The principle of smell, or that upon which this property depends, was called Spiritus Rector by Boerhaave, and is by some chemists called Aroma. We possess little more than conjectures respecting this substance, which at all events appears to be of extreme subtilty. When plants are distilled by a gentle heat upon a water-bath, the principle of smell comes over, united either with the water or with the essential oil, of either of which it appears to compose an extremely small part. Some plants may be distilled with ardent spirit to advantage, their fragrance uniting with this menstruum.

From these and other circumstances, the aromatic principle has been supposed to consist of saline, oleaginous, or spirituous matter; and some have conjectured it to be a peculiar acrimiform fluid, or gas, of very sparing solubility in the several fluids that combine with it. On this occasion we can only observe, that, notwithstanding the rational proceeding of reasoning from the facts we know to those which still remain to be investigated, yet there are many experiments which must be made before we can pretend to speak with accuracy upon this subject.

ARRACK. A spirituous liquor imported from the East Indies. It is chiefly manufactured at Batavia, and at Goa upon the Malabar coast. There are various accounts of the processes and materials used in making it; and the disagreement of these accounts seems to arise from the general appellation of *Arrack* being given, in the East Indies, to every kind of spirituous liquor; and also from the disposition which the Dutch so eminently possess of endeavouring to keep their manufacturing processes to themselves. It is certain that the flavours of the several kinds of arrack differ as much from each other, as those of brandy, rum, corn spirits, or any other of the spirituous liquors of Europe. The materials from which ardent spirit is distilled in the East Indies, are rice, melasses, and toddy, or the juice of the cocoa-nut tree. The Chinese distil a spirit from rice, which they distinguish by the name of Sam-shu, and of which considerable quantities are exported to Batavia, for the purpose, as it is said, of being converted into arrack by a second distillation; though perhaps it may be consumed among the numerous Chinese who inhabit that city. The common Batavia arrack appears to be distilled from a mixture of the wort or infusion of rice and the toddy, after both have passed through the vinous process. And to these, according to circumstances, it seems they add other ingredients, particularly spices.

Of European spirits the common malt spirit before rectification resembles arrack the most. Arrack is reckoned less intoxicating than rum or brandy; but this difference arises from its being very seldom of equal strength. Of five specimens procured from different channels, I found the specific gravity between 965 and 967, water being 1000; whence it follows that proof spirit lowered with about $\frac{3}{4}$ of its bulk of water, would have been of the same strength as this arrack.

ARSENIC in the metallic state, or the regulus of arsenic, is of a bright yellowish white colour, subject to tarnish and grow black by exposure to air. It is brittle, and when broken exhibits a laminated texture. In close vessels it sublimes entire; but burns with a small flame, if respirable air be present.

The arsenic met with in commerce has the form of white calx. It is brought chiefly from the cobalt works in Saxony, where zaffre is made. Cobalt ores contain much arsenic, which is driven off by long torrefaction. The ore is thrown into a furnace resembling a baker's oven, with a flue, or horizontal chimney, nearly two hundred yards long, into which the fumes pass, and are condensed into a greyish or blackish powder. This is refined by a second sublimation in close vessels, with a
little

little potash, to detain the impurities. As the heat is considerable, it melts the sublimed flowers into those crystalline masses which are met with in commerce.

The calx of arsenic is so far in the saline state, as to be soluble in about eighty times its weight of water, at the temperature of 60° , or in fifteen times its weight of boiling water.

The regulus may be obtained from this calx, either by quickly fusing it together with twice its weight of soft soap and an equal quantity of alkali, and pouring it out, when fused, into an hot iron cone; or by mixing it in powder with oil, and exposing it in a matraass to a sand heat. This process is too offensive to be made but in the open air, or where a current of air carries off the fumes. The decomposed oil first rises; and the regulus is afterwards sublimed, in the form of a flaky metallic substance.

Vitriolic acid does not attack the regulus of arsenic, nor its calx, when cold; but, if it be boiled upon this semi-metal, vitriolic acid air is emitted, a small quantity of sulphur sublimes, and the arsenic is reduced to the calciform state. Boiling vitriolic acid dissolves the calx of arsenic; but scarcely retains any portion of it when cold. The calx of arsenic is considerably less volatile when vitriolic acid is present or mixed with it; but it is said that washing deprives it of the acid, and restores its properties.

Nitrous acid readily attacks and calcines the regulus of arsenic: it likewise dissolves the calx of this semi-metal, in considerable quantities, by the assistance of heat; and affords a crystallized deliquescent salt by evaporation, which does not detonate on red-hot coals. The calx of arsenic is acidified by the action of nitrous acid distilled from it.

Boiling marine acid dissolves the regulus, and also the calx, of arsenic; but affects it very little when cold. This solution affords precipitates upon the addition of alkalis.

The dephlogisticated or aerated marine acid converts the calx of arsenic into arsenical acid.

The calx of arsenic acts, in many instances, like an acid. It decomposes nitre by distillation; the nitrous acid flying off, and the arsenical salt of Macquer remaining behind. In this process, the nitrous acid appears to acidify the calx. Quadrangular nitre is affected in the same manner. When the white calx of arsenic is distilled with sulphur, volatile vitriolic acid flies off, and a combination of a yellow colour, called Orpiment, is produced; which appears to consist of sulphur united to regulus of arsenic: that is to say, part of the sulphur receives vital air from the calx; to which, according to the ancient system, it communicates phlogiston; and in this manner the sulphur becomes converted into vitriolic acid, while the arsenical calx is reduced, and combines with the rest of the sulphur. The combination of sulphur and arsenic which has been fused is of a red colour, and known by the name of Realgar, or Realgar. Realgar appears to be less volatile than orpiment, or the yellow combination; for it remains at the bottom while the other sublimes: but in what respect they differ from each other has not been well ascertained. It is not improbable but that the orpiment may contain the calx in a more reduced state than the realgar.

Saline liver of silver dissolves the calx of arsenic, but more readily attacks the regulus.

Watery solutions of fixed alkalis dissolve the calx of arsenic; and if they be loaded with it, by means of heat, a brown tenacious mass is produced, which acquires solidity, has a disagreeable smell, and is called Hepar of Arsenic. Mineral acids precipitate part of the arsenic; but a portion of it being acidified, adheres more tenaciously to the alkali. The acids occasion no precipitation from the solution of arsenic in the

volatile alkali. It is not easy to explain what happens in this case without further experiments. The solutions of calx of arsenic in alkalis differ much in their properties from the combination which is produced when the nitrous salts are decomposed by its means. This difference is accounted for from the consideration that it is calx of arsenic in the first case, and the acid in the latter, which combines with the alkalis.

A solution of the calx of arsenic acts upon metals in the humid way, most probably in consequence of its approach to the acid state.

Regulus of arsenic is soluble in unctuous oil in a boiling heat: the solution is black, and has the consistence of salve cold. Most metals unite with arsenic; which most probably exists in the reguline state in such as possess the metallic brilliancy. The calx, more or less acidified, is common in many minerals.

Arsenic is used in a variety of arts. It enters into metallic combinations wherein a white colour is required. Glass manufacturers use it; but its effect in the composition of glass does not seem to be clearly explained. Orpiment and realgar are used as pigments. Some attempts have been made to introduce it into medicine; but, as it is known to be a most violent poison, it is probable that the fear of its bad effects may long deprive society of the advantages it might afford in this way. See ACID OF ARSENIC.

ARUM. The common ARUM, or Wakerobin, is a plant of extreme acrimony: the fresh root, slightly chewed, seems to burn and corrode the tongue; and oftentimes its pungent impression continues for two or three days. The seat of this acrimony has hitherto eluded our enquiries: the distilled water and spirit have nothing of it, and the watery and spirituous extracts exceedingly little; and yet the root is by these operations deprived of it.

Greatest part of the acrimony is destroyed by simple excision: the dry root appears white and farinaceous, and affects the tongue but little. In this state it is given medicinally for attenuating viscid juices: formerly it was used as starch for linen, before the discovery of that from wheat; and it is said to have occasioned a rawness and soreness of the hands very difficultly relievable by ointments. In some parts of France it is still employed in bleaching; being supposed by its corrosive quality to dissolve unctuosities, and make the linen white.

From an ounce of the dry root Neumann obtained scarcely a scruple of spirituous extract: the same quantity yielded of watery extract near three drams. The first had some slight pungency; the latter none.

ASAFÆTIDA is obtained from a large umbelliferous plant growing in Persia. The root resembles a large parsnep externally, of a black colour: on cutting it transversely, the asafætida exudes in form of a white thick juice, like cream; which, from exposure to the air, becomes yellower and yellower, and at last of a dark brown colour. It is very apt to run into putrefaction; and hence those who collect it, carefully defend it from the sun. The fresh juice has an excessively strong smell, which grows weaker and weaker upon keeping: a single dram of the fresh fluid juice smells more than a hundred pounds of the dry asafætida brought to us. The Persians are commonly obliged to hire ships on purpose for its carriage, as scarcely any one will receive it along with other commodities, its stench infecting every thing that comes near it.

The common asafætida of the shops is of a yellowish or brownish colour, unctuous and tough, of an acrid or biting taste, and a strong disagreeable smell, resembling that of garlic. From four ounces Neumann obtained, by rectified spirit, two ounces six drams and a half of resinous extract; and afterwards, by water, three drams half a scruple of gummy extract; about six drams and a scruple of earthy matter remaining undissolved. On applying water at first, he gained, from four ounces, one ounce three scruples and a half of gummy extract. The same quantity yielded, with strong

French

French wine, two ounces and a half and fifteen grains; from which about one fifth may be deducted, for the solid matter contained in the wine. Schroder says that asafœtida may be dissolved over the fire, in water, vinegar, or wine; but only a part of it can be dissolved in any of these liquors. The smell of the asafœtida resides wholly in an essential oil which arises in distillation both with water and spirit: four ounces, distilled with water, yielded about a dram of oil.

ASBESTOS, or ASBESTUS. The most obvious characters of the asbestos are, a greater or less degree of flexibility, and their resisting the fire. The **AMIANTHUS** is often confounded with it. Cronstedt distinguishes two kinds:—The asbestos which is composed of soft and thin membranes, and is the amianthus of Wallerius. The membranes of this are either parallel, in which case he calls it Mountain Leather; or twisted, which he distinguishes by the name of Mountain Cork. Both these kinds are white when pure; or of a yellowish brown when contaminated with iron. The impure sort melts pretty easily into a black slag.—The second kind of asbestos distinguished by Cronstedt, has its fibres fine and flexible, and either parallel, of a light green or white colour; or of a greenish colour, somewhat more brittle, and contaminated with iron. This last is fusible into a semi-transparent glass. There is also a light green martial asbestos, with broken fibres, which belongs to this kind.

The ancients manufactured cloth out of the fibres of asbestos, for the purpose, it is said, of wrapping up the bodies of the dead, when exposed on the funeral pile. Several moderns have likewise succeeded in making this cloth; the chief artifice of which seems to consist in the admixture of flax and a liberal use of oil; both which substances are afterwards consumed by exposing the cloth for a certain time to a red heat. Although the cloth of asbestos, when soiled, is restored to its primitive whiteness by heating in the fire; it is found nevertheless, by several authentic experiments, that its weight diminishes by such treatment. The fibres of asbestos, exposed to the violent heat of the blow-pipe, exhibit slight indications of fusion; though the parts, instead of running together, moulder away, and part fall down, while the rest seem to disappear before the current of air. Ignition impairs the flexibility of asbestos in a slight degree.

According to Bergman, the fibrous asbestos contains from 53 to 74 parts of siliceous earth, from 12 to 28 of mild magnesia, from 7 to 14 of mild calcareous earth, from 2 to 6 of clay, and from 1 to 10 of iron; the whole mass being supposed to be divided into 100 parts. The martial asbestos contains 62 of siliceous earth, 13,7 of magnesia, 12 of calcareous earth, 1,7 of clay, and 10,6 of iron. This affords a white slag by fusion.

The mountain cork or leather contains in the hundred from 56 to 62 parts of siliceous earth, from 22 to 26 of mild magnesia, from 10 to 12 of mild calcareous earth, from 2 to near 3 of clay, and about 3 of iron.

ASHES. The fixed residue of combustible substances which remains after they have been burned, is called Ashes. In chemistry it is most commonly used to denote the residue of vegetable combustion. Vegetable ashes contain alkali, which may be washed out with water; and the insoluble part is found to consist of a calcareous earth for the most part, some clay, and a much less portion of magnesia. All these products vary in the different species of vegetables. Most plants afford likewise iron and manganese; and Mr. Sage, by experiments which have been verified by other chemists, has proved that gold is a very common ingredient, though in so small a quantity as by no means to pay the charge of extracting it.

ASPHALTUM. This substance, likewise called Bitumen Judaicum, or Jews Pitch, is a smooth, hard, brittle, black or brown substance, which breaks with a polish, melts

melts easily when heated, and when pure burns without leaving any ashes. It is found in a soft or liquid state on the surface of the Dead Sea, but by age grows dry and hard. The same kind of bitumen is likewise found in the earth in other parts of the world; in China, America; and some parts of Europe, as the Carpathian hills, France, Neuchatel, &c. Its specific gravity, according to Boyle, is 1400. Ardent spirit and ether act upon it but very slightly and partially. Water does not alter it; neither is it soluble in olive oil, or the essential oils of anniseed or turpentine. According to Neumann, the asphaltum of the shops is a very different compound from the native bitumen; and varies, of course, in its properties, according to the nature of the ingredients made use of in forming it. On this account, and probably from other reasons, the use of asphaltum, as an article of the materia medica, is almost totally laid aside.

ASPIC. A plant which grows in plenty in Languedoc, in Provence, and especially on the mountain of St. Baume in France. It is a kind of lavender, pretty much like that which grows in our gardens, both with regard to its flowers, which are blue, and to the figure and green colour of its leaves. The botanists call it male lavender, *lavendula mas* in Latin. They also give it other names, as *spica nardi*, *pseudo-nardus*, &c. The oil of aspic that painters, farriers, and other artificers use, which is likewise of some use in medicine, being employed in several Galenical compositions, is extracted from the flowers and small leaves of this plant. It is very inflammable, and when once on fire it is almost impossible to extinguish it.

The true oil of aspic is white, and of an aromatic scent. It is the only dissolvent of sandarac; by which means it may be easily distinguished from that which is counterfeited, and which is nothing but oil of turpentine mixed with a little oil of petroleum.

In the above article, which is taken from Postlethwaite, the author, who refers to Savary as his authority, affirms that as sandarac, or gum sandarac, is very soluble in spirit of wine, he concludes that Mr. Savary is mistaken, and must have meant karabé, or yellow amber. I find, in fact, that gum sandarac, though it differs from resins in several essential respects, particularly in not being soluble in olive oil, agrees with them nevertheless in this particular, that alcohol dissolves it.

ASSAY, or ESSAY. This operation consists in determining the quantity of valuable or precious metal contained in any mineral or metallic mixture, by analysing a small part thereof. The practical difference between the analysis and the assay of an ore, consists in this: The analysis, if properly made, determines the nature and quantities of all the parts of the compound; whereas the object of the assay consists in ascertaining how much of the particular metal in question may be contained in a certain determinate quantity of the material under examination. Thus, in the assay of gold or silver, the baser metals are considered as of no value or consequence; and the problem to be resolved is simply, how much of each is contained in the ingot or piece of metal intended to be assayed. The examination of metallic ores may be seen under their respective titles; the present article will therefore consist of an account of the assaying of gold and silver.

To obtain gold or silver in a state of purity, or to ascertain the quantity of alloy it may contain, it is exposed to a strong heat, together with lead, in a porous crucible. This operation is called cupellation, and is performed as follows: The precious metal is put, together with a due proportion of lead, into a shallow crucible, made of burned bones, called a cupel; and the fusion of the metals is effected by exposing them to a considerable heat in a muffle, or small earthen oven, fixed in the midst of a furnace. The lead continually vitrifies,

or becomes converted into a glassy calx, which dissolves all the imperfect metals. This fluid glass, with its contents, soaks into the cupel, and leaves the precious metal in a state of purity. During the cupellation, the scoræ running down on all sides of the metallic mass, produce an appearance called circulation; by which the operator judges whether the process is going on well. When the metal is nearly pure, certain prismatic colours flash suddenly across the surface of the globule, which soon afterwards appears very brilliant and clean: this is called the brightening, and shews that the separation is ended.

After gold has passed the cupel, it may still contain either of the other perfect metals, platina or silver. The former is seldom suspected; the latter is separated by the operations called quartation and parting. Quartation consists in adding three parts of silver to the supposed gold, and fusing them together; by which means the gold becomes one fourth of the mass only. The intention of this is to separate the particles of gold from each other, so that they may not cover and defend the silver from the action of the pure nitrous acid which is to be used in the process of parting. Parting consists in exposing the mass, previously hammered or rolled out thin, to the action of boiling aqua fortis of a due strength. If the acid be not too concentrated, it dissolves the silver, and leaves the gold in a porous mass, of the original form; but, if too strong, the gold is in a powdery form, which may be washed and dried. The weight of the original metal before cupellation, and in all the subsequent stages, serves to ascertain the degree of fineness of the ingot, or ore, of which it is a part.

In estimating or expressing the fineness of gold, the whole mass spoken of is supposed to weigh twenty-four carats of twelve grains each, either real, or merely proportional, like the assayers weights; and the pure gold is called fine. Thus if gold be said to be 23 carats fine, it is to be understood that, in a mass weighing 24 carats, the quantity of pure gold amounts to 23 carats.

In such small works as cannot be assayed by scraping off a part, and cupelling it, the assayers endeavour to ascertain its quality, or fineness, by the touch. This is a method of comparing the colour, and other properties, of a minute portion of the metal, with those of small bars whose composition is known. These bars are called touch-needles; and they are rubbed upon the black basalt, which for that reason is called the touch-stone. Black flint or pottery will serve the same purpose. Sets of golden needles may consist of—Pure gold; pure gold $23\frac{1}{2}$ carats, with half a carat of silver; 23 carats of gold, with one carat silver; $22\frac{1}{2}$ carats gold, with $1\frac{1}{2}$ carat silver; and so forth, till the silver amounts to four carats; after which the additions may proceed by whole carats. Other needles may be made in the same manner, with copper instead of silver; and other sets may have the addition consisting either of equal parts silver and copper, or such proportions as the occasions of business require.

In foreign countries, where trinkets and small work are required to be submitted to the assay of the touch, a variety of needles are necessary; but they are not much used in England. They afford, however, a degree of information which is more considerable than might at first be expected. The attentive assayer not only compares the colour of the stroke made upon the touch-stone, by the metal under examination, with that produced by his needle; but will likewise attend to the sensation of roughness, dryness, smoothness, or greasiness, which the texture of the rubbed metal excites, when abraded by the stone. When two strokes perfectly alike in colour are made upon the stone, he may then wet them with aqua fortis, which will affect them very differently, if they be not similar compositions; or the stone itself may be made red-hot by the fire, or by the blow-pipe, if thin black

pottery be used; in which case the phenomena of calcination will differ, according to the nature and quantity of the alloy.

The French government has from time to time caused various experimental enquiries to be made respecting the art of assaying gold, which have thrown much light on this subject, and greatly tend to produce uniformity in the results of the operation. The latest report on this subject may be seen in the *Annales de Chimie*, vol. vi. p. 64; which may be consulted for a full account of the experiments and history of former proceedings. The general result is as follows, nearly in the words of the authors :

Six principal circumstances appear to affect the operation of parting: namely, the quantity of acid used in parting, or in the first boiling; the concentration of this acid; the time employed in its application; the quantity of acid made use of in the re-prise, or second operation; its concentration; and the time during which it is applied. From the experiments it has been shewn, that each of these unfavourable circumstances might easily occasion a loss of from the half of a thirty-second part of a carat to two thirty-second parts. The writers explain their technical language by observing that, the whole mass consisting of twenty-four carats, this thirty-second part denotes $\frac{1}{48}$ part of the mass. It may easily be conceived, therefore, that if the whole six circumstances were to exist, and be productive of errors falling the same way, the loss would be very considerable.

It therefore is indispensably necessary that one uniform process should be followed in the assays of gold; and it is a matter of astonishment that such an accurate process should not have been prescribed by government for assayers in an operation of such great commercial importance, instead of every one being left to follow his own judgment. The process recommended in the report before us is as follows.

Twelve grains of the gold intended to be assayed must be mixed with thirty grains of fine silver, and cupelled with 108 grains* of lead. The cupellation must be carefully attended to, and all the imperfect buttons rejected. When the cupellation is ended, the button must be reduced by lamination into a plate of $1\frac{1}{2}$ inch, or rather more, in length, and four or five lines in breadth. This must be rolled up upon a quill, and placed in a matrafs capable of holding about three ounces of liquid, when filled up to its narrow part. Two ounces and a half of very pure aqua fortis, of the strength of 20 degrees of Baumé's areometer must then be poured upon it; and the matrafs being placed upon hot ashes, or sand, the acid must be kept gently boiling for a quarter of an hour: the acid must then be cautiously decanted, and an additional quantity of $1\frac{1}{2}$ ounce must be poured on the metal, and slightly boiled for twelve minutes. This being likewise carefully decanted, the small spiral piece of metal must be washed with filtered river-water, or distilled water, by filling the matrafs with this fluid. The vessel is then to be reversed, by applying the extremity of its neck against the bottom of a crucible of fine earth, whose internal surface is very smooth. The annealing must then be made, after having separated the portion of water which had fallen into the crucible; and, lastly, the annealed gold must be weighed. For the certainty of this operation, two assays must be made in the same manner, together with a third assay upon gold of twenty-four carats, or upon gold whose fineness is perfectly and generally known.

* $1\frac{1}{2}$ gros. Though these doses of silver and lead appeared to be proper for all operations of assaying gold, the commissaries observe, nevertheless, that gold of a lower title than eighteen carats may be alloyed with two parts, and even less, of silver; in order that the small mass of metal, when it comes to be laminated, may not be too thin, so as to break in pieces during the parting.

No conclusion must be drawn from this assay, unless the latter gold should prove to be of the fineness of twenty-four carats exactly, or of its known degree of fineness; for, if there be either loss or surplus, it may be inferred that the two other assays, having undergone the same operation, must be subject to the same error. The operation being made according to this process, by several assayers, in circumstances of importance, such as those which relate to large fabrications, the fineness of the gold must not be depended on, nor considered as accurately known, unless all the assayers have obtained a uniform result without communication with each other. The authors observe, however, that this identity must be considered as existing to the accuracy of half of the thirty-second part of a carat. For, notwithstanding every possible precaution or uniformity, it very seldom happens that an absolute agreement is obtained between the different assays of one and the same ingot, because the ingot itself may differ in its fineness in different parts of its mass.

The assaying of silver does not differ from that of gold, excepting that the parting operation is not necessary. A certain small portion of the silver is absorbed by the cupel, and the more when a larger quantity of lead is used, unless the quantity of lead be excessive; in which case most of it will be scorified before it begins to act upon the silver. Messrs. Hellot, Tillet, and Macquer, from their experiments made by order of the French Government, have ascertained that four parts of lead are requisite for silver of eleven pennyweights twelve grains fine; six parts of lead for silver of eleven pennyweights; eight parts lead for silver of ten pennyweights; ten parts lead for silver of nine pennyweights; and so on in the same progression.

ASTRINGENT PRINCIPLE. The effect, called astringency, considered as distinguishable by the taste, is incapable of being defined. It is perceived in the husks of nuts, of walnuts, in green tea, and eminently in the nut gall; and most probably in all these is produced by the basis of the acid of galls not perfectly acidified. If the nature and affinities of this substance were well ascertained, it would probably tend to throw great light on the art of dying. *See* ACID OF GALLS.

ATHANOR. A kind of furnace, which has long since fallen into disuse. The very long and durable operations of the ancient chemists rendered it a desirable requisite, that their fires should be constantly supplied with fuel in proportion to the consumption. The athanor furnace was peculiarly adapted to this purpose. Besides the usual parts, it was provided with an hollow tower, into which charcoal was put. The upper part of the tower, when filled, was closely shut by a well-fitted cover; and the lower part communicated with the fire-place of the furnace. In consequence of this disposition, the charcoal subsided into the fire-place gradually as the consumption made room for it; but that which was contained in the tower was defended from combustion by the exclusion of a proper supply of vital air.

ATMOSPHERE. *See* AIR ATMOSPHERICAL.

ATTRACTION. The instances of attraction which are exhibited by the phenomena around us are exceedingly numerous, and continually present themselves to our observation. The effect of gravity, which causes the weight of bodies, is so universal, that we can scarcely form an idea how the universe could subsist without it. Other attractions, such as those of magnetism and electricity, are likewise observable; and every experiment in chemistry tends to shew that bodies are composed of various principles or substances, which adhere to each other with various degrees of force, and may be separated by the known methods. It is a question among philosophers, whether all the attractions which obtain between bodies be referable to one general cause modified by circumstances, or whether various original and distinct causes act upon the particles of bodies at one and the same time. The philosophers at the beginning of the present century were disposed to consider the several attractions as es-

entially different, because the laws of their action differ from each other ; but the moderns appear disposed to generalize this subject, and to consider all the attractions which exist between bodies, or at least those which are permanent, as depending upon one and the same cause, whatever it may be, which regulates at once the motions of the immense bodies which circulate through the celestial spaces, and those minute particles which are transferred from one combination to another in the operations of chemistry. The earlier philosophers observed, for example, that the attraction of gravitation acts upon bodies with a force which is inversely as the squares of the distances ; and from mathematical deduction they have inferred, that the law of attraction between the particles themselves follows the same ratio : but, when their observations were applied to bodies very near each other, or in contact, an adhesion took place, which is found to be much greater than could be deduced from that law applied to the centres of gravity. Hence they concluded, that the cohesive attraction is governed by a much higher ratio, and probably the cubes of the distances. The moderns, on the contrary, among whom are Bergmann, De Morveau, and others, have remarked that these deductions are too general, because for the most part drawn from the consideration of spherical bodies, which admit of no contact but such as is indefinitely small, and exert the same powers on each other, whichever side may be obverted. They remark likewise, that the consequence depending on the sum of the attractions in bodies not spherical, and at minute distances from each other, will not follow the inverted ratio of the square of the distance taken from any point assumed as the centre of gravity, admitting the particles to be governed by that law ; but that it will greatly differ, according to the sides of the solid which are presented to each other, and their respective distances ; inasmuch that the attractions of certain particles indefinitely near each other will be indefinitely increased, though the ratio of the powers acting upon the remoter particles may continue nearly the same.

This doctrine, which however requires to be much more strictly examined by the application of mathematical principles, obviously points to a variety of interesting consequences. The polarity of particles, or their disposition to present themselves in their approach to each other in certain aspects, though it has been treated as a chimerical notion by a few superficial writers, is one of the first of these results ; and may be not unaptly shown by the experiment of floating bodies upon water, which depress the surface of that fluid, and form a cavity into which they subside, and produce an appearance of attraction by rushing together ; in which case their mode of application to each other is considerably governed by their figure, which causes them to turn round, and apply themselves to each other in such a manner as that the sum of the forces that act upon the two bodies may be nearly in equilibrio.

As a proof that gravitation and chemical attraction are two distinct properties, instead of the latter being a modification of the former, it has been noticed that this last is not governed by the masses or specific gravities of the particles. Thus, for example, since spirit of wine dissolves resin, and water does not ; it would follow as an inference upon this system, that the particles of the spirit are denser than those of the water ; whereas the opposite conclusion might have been drawn, if the experiment had been made with gum instead of resin ; this substance being dissolved by water, and not by spirit. Nevertheless, it is a good answer to this objection, that admitting the masses to govern the attractions, yet the modifications of figure may be such as even to have a greater influence in the total effect than the mass itself. Thus it may be conceived that two cubes of lead may adhere more strongly by their flat surfaces than two spheres of gold, which cannot touch each other but in a point ; and the superiority of attraction in the one

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case over the other may prevail in all the small distances to which chemical effects extend themselves; not to mention that magnitude of particles will as greatly modify the consequences as figure itself.

These are speculations which, with regard to the present state of chemistry, stand in much the same situation as the theory of gravity, which is minutely described in Plutarch *, did with regard to astronomy before the time of Newton. As the celestial phenomena were formerly arranged from observation merely, but are now computed from the physical cause, gravitation; so, at present, chemistry is the science of matter of fact duly arranged, without the assistance of any extensive theory immediately deduced from the figures, volumes, densities, or mutual actions of the particles of bodies. What it may hereafter be, must depend on the ability and research of future chemists; but at present we must dismiss this remoter part of theory, to attend more immediately to the facts.

That the parts of bodies do attract each other, is evident from that adhesion which produces solidity, and requires a certain force to overcome it. For the sake of perspicuity, the various effects of attraction have been considered as different kinds of affinity, or powers. That power which physical writers call the attraction of cohesion, is generally called the attraction of aggregation by chemists. Aggregation is considered as the adhesion of parts of the same kind. Thus, a number of pieces of brimstone united by fusion form an aggregate, whose parts may be separated again by mechanical means. These parts have been called integrant parts: that is to say, the minutest parts into which a body can be divided, either really or by the imagination, so as not to change its nature, are called integrant parts. Thus, if sulphur and an alkali be combined together, and form liver of sulphur, we may conceive the mass to be divided and subdivided to an extreme degree, until at length the mass consists of merely a particle of brimstone and a particle of alkali. This then is an integrant part; and if it be divided further, the effect which chemists call decomposition will take place; and the particles, consisting no longer of liver of sulphur, but of sulphur alone and alkali alone, will be what chemists call component parts or principles.

The union of bodies in a gross way is called mixture. Thus, sand and an alkali may be mixed together. But, when the very minute parts of a body unite with those of another so intimately as to form a body which has properties different from those of either of them, the union is called combination, or composition. Thus, if sand and an alkali be exposed to a strong heat, the minute parts of the mixture combine, and form glass.

The earlier chemists were very desirous of ascertaining the first principles, or elements, of bodies; and they distinguished by this name such substances as their art was incapable of rendering more simple. They seem however to have overlooked the obvious circumstance, that the limits of art are not the limits of nature. At present we hear little concerning elements. Those substances which we have not hitherto been able to analyse, or which, if decomposed, have hitherto eluded the observation of chemists, are indeed considered as simple substances relative to the present state of our knowledge, but in no other respect; for a variety of experiments give us reason to hope that future enquiries may elucidate their nature and composition. Some writers, calling those simple substances by the name of Primary Principles, have distinguished compounds of these by the name of Secondary Principles, which they suppose to enter again into combinations without decomposition or change. It must be confessed, nevertheless, that no means have

* In his imperfect Treatise *De Facie in Orbe Lunæ*.

yet been devised to shew whether any such subordination of principles exists. We may indeed discover that a compound body consists of three or more principles; but whether two of these be previously united, so as to form a simple substance with relation to the third, or what in other respects may be their arrangement, we do not know.

If two solid bodies, disposed to combine together, be brought into contact with each other, the particles which touch will combine, and form a compound; and if the temperature at which this new compound assumes the fluid form be higher than the temperature of the experiment, the process will go no farther, because this new compound being interposed between the two bodies will prevent their further access to each other: but if, on the contrary, the freezing point of the compound be lower than this temperature, liquefaction will ensue; and the fluid particles being at liberty to arrange themselves according to the law of their attractions, the process will go on, and the whole mass will gradually be converted into a new compound in the fluid state. An instance of this may be exhibited by mixing common salt and perfectly dry pounded ice together. The crystals of the salt alone will not liquefy unless very much heated; the crystals of the water, that is to say, the ice, will not liquefy unless heated as high as thirty-two degrees of Fahrenheit; and we have of course supposed the temperature of the experiment to be lower than this, because our water is in the solid state. Now it is a well-known fact that brine, or the saturated solution of sea salt in water, cannot be frozen unless it be cooled thirty-eight degrees lower than the freezing point of pure water. It follows then, that if the temperature of the experiment be higher than this, the first combinations of salt and ice will produce a fluid brine, and the combination will proceed until the temperature of the mass has gradually sunk as low as the freezing point of brine; after which it would cease, if it were not that surrounded bodies continually tend to raise the temperature. And accordingly it is found by experiment, that if the ice and the salt be previously cooled below the temperature of freezing brine, the combination and liquefaction will not take place. *See HEAT.*

The instances in which solid bodies thus combine together not being very numerous, and the fluidity which ensues immediately after the commencement of this kind of experiment, have induced several chemists to consider fluidity in one or both, of bodies applied to each other, to be a necessary circumstance, in order that they may produce chemical action upon each other. *Corpora non agunt nisi sint fluida.*

If one of two bodies applied to each other be fluid at the temperature of the experiment, its parts will successively unite with the parts of the solid, which will by that means be suspended in the fluid, and disappear. Such a fluid is called a Solvent or Menstruum; and the solid body is said to be dissolved.

Some substances unite together in all proportions. In this way the acids unite with water. But there are likewise many substances which cannot be dissolved in a fluid at a settled temperature, in any quantity beyond a certain proportion. Thus, water will dissolve only about one-fourth of its weight of common salt, and if more be added it will remain solid. A fluid which holds in solution as much of any substance as it can dissolve, is said to be saturated with it. But saturation with one substance is so far from preventing a fluid from dissolving another body, that it very frequently happens that the solvent power of the compound exceeds that of the original fluid itself. Chemists likewise use the word Saturation in another sense; in which it denotes such an union of two bodies as produces a compound the most remote in its properties from the properties of the component parts themselves.

selves. In other combinations, where one of the principles predominates, the other is said to be supersaturated, and the other principle is said to be undersaturated.

Heat in general increases the solvent power of fluids, probably by preventing part of the dissolved substance from congealing, or assuming the solid form.

It often happens, that bodies which have no tendency to unite are made to combine together by means of a third, which is then called the Medium. Thus, water and fat oils are made to unite, by the medium of an alkali, in the combination called Soap. Some writers, who seem desirous of multiplying terms, call this tendency to unite the *Affinity of Intermedium*.

It very frequently happens, on the contrary, that the tendency of two bodies to unite, or remain in combination together, is weakened or destroyed by the addition of a third. Thus, spirit of wine unites with water in such a manner as to separate most salts from it. A striking instance of this is seen in a saturated or strong solution of nitre in water. If to this there be added an equal measure of strong ardent spirit, the greatest part of the nitre instantly falls down. Thus magnesia is separated from a solution of Epsom salt by the addition of an alkali which combines with the vitriolic acid, and separates the earth. The principle which falls down is said to be precipitated, and in many instances is called a Precipitate. Some modern chemists use the term Precipitation in a more extended, and rather forced sense; for they apply it to all substances thus separated. In this enunciation therefore they would say, that the vegetable alkali precipitates the mineral alkali from a solution of common salt, though no visible separation or precipitation takes place; for the mineral alkali, when disengaged from its acid, is still suspended in the water by reason of its solubility.

From an infinite number of facts of this nature it is clearly ascertained, not as a probable hypothesis but as simple matter of fact, that some bodies have a stronger tendency to unite than others; and that the union of any substance with another will exclude, or separate, a third substance which might have been previously united with one of them; excepting only in those cases wherein the new compound has a tendency to unite with that third substance, and form a triple compound. This preference of uniting, which a given substance is found to exhibit with regard to other bodies, is by an easy metaphor called *Elective Attraction*, and is subject to a variety of cases, according to the number and the powers of the principles which are respectively presented to each other. The cases which have been most frequently observed by chemists, are those called *Simple Elective Attractions*, and *Double Elective Attractions*.

When a simple substance is presented or applied to another substance compounded of two principles, and unites with one of these two principles so as to separate or exclude the other, this effect is said to be produced by *simple elective attraction*.

It may be doubted whether any of our operations have been carried to this degree of simplicity. All the chemical principles we are acquainted with, are simple only with respect to our power of decomposing them; and the daily discoveries of our contemporaries tend to decompose these substances which chemists a few years ago considered as simple. Without insisting however upon this difficulty, we may observe that water is concerned in all the operations which are called *Humid*; and beyond a doubt modifies all the effects of such bodies as are suspended in it. In the dry way, the element of fire, or matter of heat, admitted perhaps too rashly by a very great number of chemists, tends equally to modify the effects of processes in
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the dry way; and at all events, the variations of temperature, whether arising from an actual igneous fluid, or from a mere modification of the parts of bodies, tend greatly to disturb the effects of elective attraction. These causes render it difficult to point out an example of simple elective attraction, which may in strictness be reckoned as such. If however we overlook the effect of water, we may then point out various examples. Thus, as we have just observed, an alkali added to a solution of Epsom salt throws down the magnesia, and itself forms a salt of another kind in solution. So likewise, in the dry way, if a combination of lead and sulphur be fused with iron, the sulphur unites with this last, and leaves the lead free.

It will be observed however, that even in these instances the substances made use of are not universally admitted to be simple. All chemists now admit that the acids consist of vital air united to a peculiar basis in each; and lead, iron, and sulphur are all supposed by the phlogistians to contain the principle of inflammability.

Double elective attraction takes place when two bodies, each consisting of two principles, are presented to each other, and mutually change a principle of each; by which means two new bodies, or compounds, are produced of a different nature from the original compounds.

Under the same limitations as were pointed out in speaking of simple elective attraction, we may offer instances of double elective attraction. Let mercury be dissolved to saturation in the nitrous acid, the water will then contain a nitro-mercurial salt. Again, let vegetable alkali be dissolved to saturation in the vitriolic acid, and the result will be a solution of vitriolated tartar. If mercury were added to the solution of vitriolated tartar, it would indeed tend to unite with the acid, but would produce no decomposition; because the elective attraction of the acid to the alkali is the strongest. So likewise, if the nitrous acid alone be added to the solution of vitriolated tartar, its tendency to unite with the alkali, strong as it is, will not effect any change, because the alkali is already in combination with a stronger acid. But if the mercurial salt, or combination of mercury with nitrous acid, be added to the solution of vitriolated tartar, a change of principles will take place, the vitriolic acid will quit the alkali, and unite with the mercury, while the nitrous acid combines with the alkali; and these two new salts, namely Common Nitre, and the Vitriolic Salt of Mercury, may be obtained separately by crystallization.

The most remarkable circumstance in this process is, that the joint effects of the attractions of the vitriolic acid to mercury, and the nitrous acid to alkali, prove to be stronger than the sum of the attractions between the vitriolic acid and the alkali, and between the nitrous acid and the mercury; for, if the sum of these two last had not been weaker, the original combinations would not have been broken. Mr. Kirwan, who first in the year 1782 considered this subject with that attention it deserves, calls the affinities which tend to preserve the original combinations, the Quiescent Affinities. He distinguishes the affinities or attractions which tend to produce a change of principles, by the name of the Divellent Affinities. Some eminent chemists are disposed to consider as effects of double affinities those changes of principles only which would not have taken place without the assistance of a fourth principle. Thus, the mutual decomposition of Glauber's salt and common nitre, in which the alkalis are changed, and vitriolated tartar with quadrangular nitre are produced, is not considered by them as an instance of double decomposition; because the nitre would have been decomposed by simple elective attraction, upon the addition of either of the two principles of the vitriolated tartar. But as there is no doubt that the two principles effect the decomposition with much greater energy,

energy, and as this distinction does not appear to be of any use, it seems unnecessary to insist upon it.

There are various circumstances which modify the effects of elective attraction, and have from time to time misled chemists in their deductions. The chief of these is the temperature, which, acting differently upon the several parts of compounded bodies, seldom fails to alter, and frequently reverses, the effects of the affinities. Thus, if spirit of wine be added to the solution of nitre, it unites with the water, and precipitates the salt at a common temperature. But if the temperature be raised, the spirit rises on account of its volatility, and the salt is again dissolved. Thus again, if vitriolic acid be added, in a common temperature, to a combination of phosphoric acid and lime, it will decompose the salt, and disengage the phosphoric acid; but if this same mixture of these principles be exposed to a considerable heat, the vitriolic acid will have its attraction to the alkali so much diminished, that it will rise, and give place again to the phosphoric, which will combine with the lime. Again, mercury kept in a degree of heat very nearly equal to volatilizing it will absorb vital air, and become converted into the red calx called Precipitate per se; but if the heat be augmented still more, the vital air will assume the elastic state, and fly off, leaving the mercury in its original state. Numberless instances of the like nature continually present themselves to the observation of chemists, which are sufficient to establish the conclusion, that the elective attractions are not constant but at one and the same temperature.

Many philosophers are of opinion, that the variations produced by change of temperature arise from the elective attraction of the matter of heat itself. But there are no decisive experiments either in confirmation or refutation of this hypothesis.

If we except the operation of heat, which really produces a change in the elective attractions, we shall find that most of the other difficulties attending this subject arise from the imperfect state of chemical science. If to a compound of two principles a third be added, the effect of this must necessarily be different according to its quantity, and likewise according to the state of saturation of the two principles of the compounded body. If the third principle which is added be in excess, it may dissolve and suspend the compound which may be newly formed, and likewise that which might have been precipitated. The metallic solutions, decomposed by the addition of an alkali, afford no precipitate in various cases when the alkali is in excess; because this excess dissolves the precipitate, which would else have fallen down. If, on the other hand, one of the two principles of the compound body be in excess, the addition of a third substance may combine with that excess, and leave a neutral substance, exhibiting very different properties from the former. Thus, if cream of tartar, which is a salt of difficult solubility, consisting of the vegetable alkali united to an excess of the acid of tartar, be dissolved in water, and chalk be added, the excess unites with part of the lime of the chalk, and forms a scarcely soluble salt; and the neutral compound which remains after the privation of this excess of acid is a very soluble salt, greatly differing in taste and properties from the cream of tartar. The metals and the acids likewise afford various phenomena, according to their degree of calcination or acidification. A determinate calcination is in general necessary for the solution of metals in acids; and the acids themselves act very differently, accordingly as they are more or less acidified. Thus, the fuming nitrous acid gives place to acids which are weaker than the pale nitrous acid: the sulphureous or volatile vitriolic acid gives place to acids greatly inferior in attractive power or affinity to the dense vitriolic acid, or oil of vitriol. The de-

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ception arising from effects of this nature is in a great measure produced by the want of discrimination on the part of chemical philosophers ; it being evident, that the properties of any compound substance depend as much upon the proportion of its ingredients, as upon their respective nature.

The solubility or insolubility of principles, at the temperature of any experiment, has likewise tended to mislead chemists of inferior accuracy, who have deduced consequences from the first effects of their experiments. It is evident that many separations may ensue without precipitation ; because this circumstance does not take place unless the separated principle be insoluble, or nearly so. The mineral alkali cannot be precipitated from a solution of Glauber's salt by the addition of vegetable alkali, because of its great solubility ; but, on the contrary, the new compound itself, or vitriolated tartar, which is much less soluble, may fall down if there be not enough water present to suspend it. No certain knowledge can therefore be derived from the appearance or the want of precipitation, unless the products be carefully examined. In some instances all the products remain suspended, and in others they all fall down, as may be instanced in the decomposition of martial vitriol by lime. Here the acid unites with the lime, and forms felenite, which is scarcely at all soluble ; and the still less soluble calx of iron, which was disengaged, falls down along with it.

Many instances present themselves, in which decomposition does not take place, but a sort of equilibrium affinity is perceived. Thus, the mineral alkali, added to cream of tartar, forms a triple salt by combining with its excess of acid. So likewise the volatile alkali combines with a portion of the acid of corrosive sublimate, and forms the triple compound distinguished by the barbarous name of *Sal Alembrothi*.

When we reflect maturely upon all the circumstances enumerated, or slightly touched upon, in the foregoing pages, we may form some idea of the extensive field of research which yet remains to be explored by chemists. If it were possible to procure simple substances, and combine two together, and to this combination of two to add one more of the other simple substances, the result of the experiment would in many cases determine, by the exclusion of one of the three, that its affinity to either of the remaining two was less than that between those two respectively. In this way it would be ascertained, in the progress of experimental enquiry, that the simple attractions of a series of substances were gradually increasing or diminishing in strength. Thus, the volatile alkali separates clay from the vitriolic acid ; magnesia, in like manner, separates the volatile alkali ; lime predominates, in the strength of affinity, over magnesia, as appears by its separating this last earth ; the mineral alkali separates the lime, and itself gives place to the vegetable alkali ; and, lastly, the vegetable alkali yields its acid to ponderous earth. The simple elective attractions of these several substances to vitriolic acid are therefore in the inverted order of their effects ; ponderous earth is the strongest ; and this is succeeded regularly by the vegetable alkali, the mineral alkali, lime, magnesia, volatile alkali, and clay. It is evident that results of this nature, being tabulated, as was first done by the celebrated Geoffroy, and last of all by Bergmann, must afford a most valuable mass of chemical knowledge. It must be remarked, however, that these results merely indicate that the powers are greater or less than each other ; but how much greater or less is not determined, either absolutely or relatively. Tables of this nature cannot therefore inform us of the effects which may take place in the way of double affinity, for want of the numerical relations between the attracting powers. Thus, when we are in possession of

the

the order of the simple elective attractions between the vitriolic acid and a series of substances, and also between the nitrous acid and the same substances; and when, in addition to this, the respective powers of each of the acids upon every one of the substances singly taken, are known, so far as to determine which will displace the other—yet we cannot thence foretell the result of applying two combinations to each other, each containing an acid united with one of the number of simple substances. Or, more concisely, a table of simple elective attractions can be of no use to determine the effects of double elective attraction, unless the absolute power of the attractions be expressed by number instead of their order merely.

It appears therefore that the present state of chemistry affords us no indication by which we may come at the results of double elective attraction without actual experiment; and, in this way, we may ascertain, whenever a double decomposition takes place, that the sum of the attractions which tend to produce the new combinations is greater than the sum of those attractions which tend to preserve the compounds in their original form. But as these attractions, in the simplest cases, are four in number, and the effect may arise from an excess or defect of any one of the four, or may be distributed in an infinity of proportions among them, it must easily be seen how numerous the difficulties are which attend these researches, and what ample space is left for exercising the sagacity of philosophers in chemical analysis.

There have not been wanting a number of eminent philosophers who have exerted themselves in attempting to discover data by which the phenomena of chemistry might be subjected to computation; and though the difficulty of the subject has hitherto prevented any thing of a conclusive nature from being done, their researches have nevertheless thrown great light on the subject. Mr. de Morveau first attempted to ascertain the proportional powers of attraction between mercury and other metals, by determining the quantity of weight or re-action necessary to separate a metallic surface of known dimensions from its contact with the face of this fluid. This method however cannot be extensively applied in chemical pursuits. Mr. Wenzel, by a series of experiments in which metallic cylinders of similar dimensions, coated on all sides with a proper varnish or covering excepting at the base, were exposed to the action of nitrous acid, thought himself authorized to conclude that the affinities of bodies with a common solvent are inversely in proportion to the time necessary for their solution; or, which is the same thing, directly in proportion to the quantities dissolved in equal small portions of time. It is very probable that this conclusion would prove true, if we could make our experiments with simple substances; but as this is not the case, his deduction cannot be applied to various fluids. For if we admit it to be true with regard to his experiments with the nitrous acid, it will not follow that his consequences can be applied to the marine acid; because a foreign circumstance intervenes, and modifies the attractions. The nitrous acid is easily decomposed, readily calcines metals, and speedily dissolves them when calcined. The marine acid appears to be scarcely, if at all, decomposable in our experiments; and therefore acts slowly, and in some instances not at all, upon metallic bases. Yet from the true test of superior affinity, namely, the decomposing of compounds already formed, the attraction of the marine acid, slow as its effects are, often proves stronger than that of the nitrous, from which it separates many metallic bases. It may likewise be observed, even with regard to the nitrous acid, that the effects not being simple, are likewise modified by the attraction of the metal for vital air, or its disposition

to part with phlogiston; or in a word, to lose sight of the two theories, its disposition to become calcined. On this account, though tin or antimony are very rapidly attacked by the nitrous acid; they give place, nevertheless, in the way of precipitation, to lead, which is much more slowly dissolved. And accordingly it is found that Mr. Wenzel's numbers, expressive of the powers of attraction, do not agree with the real experiments of double affinity.

Mr. Kirwan, to whose extensive researches the science of chemistry is so greatly indebted, has attended with peculiar sagacity to almost every attribute of chemical compounds, with a view to obtain that most desirable acquisition, the proportional strength of affinity. His Papers, which were read to the Royal Society as early as the years 1781 and 1782, are still of the highest value to chemists; though all the difficulties of the subject were far from being as well known at that period as they are at present. In consequence of Dr. Priestley's discovery of the method of exhibiting the marine acid in the æriform state, he proceeded to infer the quantities of real acid corresponding with the various densities or specific gravities of the marine acid. From these data, proceeding upon the supposition that equal quantities of the nitrous and vitriolic acids were required to saturate the same quantity of fixed alkali as was saturated by the marine acid, he formed tables of the quantities of real acid contained in those fluid acids, at different densities. He proceeded to make experiments for ascertaining the quantities of real acid (upon this supposition, together with an induction of the bases and water) contained in the earthy and alkaline salts: after which he proceeded to enquire into the quantities of phlogiston contained in the several kinds of air, previously exhibiting several cogent reasons for considering pure inflammable air as phlogiston, or the inflammable principle. These, as being foreign to our present object, we pass over; and hasten to the most interesting part of his third or conclusive Paper.

After examining the effects of the mineral acids upon metallic substances, and slightly considering what had been previously done by Bergmann, Geoffroy, Mörveau, and Wenzel, he lays it down as an axiom, that the quantity of real acid necessary to saturate a given weight of each basis, is inversely as the affinity of each basis to such acid; and also, that the quantity of each basis requisite to saturate a given quantity of each acid, is directly as the affinity of such acid to each basis.

He then exhibits a table in which equal quantities of the three ancient mineral acids are shewn to take up various quantities of the several bases, mineral alkali, calcareous earth, volatile alkali, magnesia, and earth of alum; the quantities of vegetable alkali being equal in all three: because, by his supposition, the quantities of real acid are taken to be as the quantities of this substance they are capable of saturating. He then goes further, and assumes the numerical expression of the quantity of any basis taken up by an acid, as the expression of its affinity with such basis; and, on this foundation, he goes on to calculate the effects of double decompositions and combinations. In these, he distinguishes the powers which tend to decompose by the name of Divellent Affinities; and those which tend to preserve the original combinations, he calls Quiescent Affinities. Thus, since a decomposition will always take place when the sum of the divellent affinities is greater than that of the quiescent; and, on the contrary, since no decomposition will happen when the sum of the quiescent affinities is superior or equal to that of the divellent: all we have to do therefore is to compare the sums of these powers. In this way, by the assistance of his general principle, he exhibits various instances of the application of this doctrine. For example, if vitriolated tartar and the nitrous

Salt

salt of lime be mixed together, a double decomposition will take place; the lime quitting the nitrous acid, and forming selenite with the vitriolic acid; at the same time that the vegetable alkali quits this last acid, and forms nitre by uniting with the nitrous acid. And, on Mr. Kirwan's principles, this is explained as follows:

One hundred grains of his real vitriolic acid dissolve two hundred and fifteen grains of vegetable alkali; its attraction to the alkali will therefore be expressed by the number 215. Again, one hundred grains of real nitrous acid, likewise estimated by Mr. Kirwan's original supposition, will dissolve 96 grains of calcareous earth to saturation: the affinity of nitrous acid to calcareous earth is therefore taken to be 96. These affinities, namely of the vitriolic acid to the alkali, and of the nitrous acid to the earth, tend to preserve the combinations, and consequently are the quiescent affinities; and their sum amounts to 215, added to 96, that is, 311. On the other hand, the nitrous acid tends to combine with the vegetable alkali with the same power as the vitriolic, because Mr. Kirwan has assumed that the tendency towards this substance is alike in all acids, or at least in the three mineral acids; this affinity therefore is expressed by 215. But the other divellent affinity, namely that of vitriolic acid to calcareous earth, being expressed by the quantity of that substance which one hundred grains of the real vitriolic acid takes up to saturation, will be denoted by 110. The divellent affinities consequently amount to 215 added to 110; that is, 325. And because this divellent power, 325, is greater than the quiescent power 311, a decomposition will take place.

After explaining and elucidating the effects of solubility, and the specific heats of substances, on the action of chemical affinity, this author proceeds to exhibit the attractive powers of the three mineral acids to metallic substances in his way; that is, by ascertaining how much of each is taken up by a hundred grains of his real acid. I do not give these numbers, though they exhibit valuable facts; because much remains yet to be done before Mr. Kirwan's deductions respecting the quantities of real acid, and the measures of affinity, can be admitted as established parts of chemical theory.

In the first place, as Mr. Kirwan himself observes, there can be no deduction made of the quantities of real acid from the quantities of vegetable alkali which acids of various kinds saturate, if it should appear that the attractions of these acids towards that substance should differ as well as their quantities. And this supposition, that they do not differ, is not only gratuitous, but inconsistent with the general tenour of chemical facts; among which it would be difficult, and perhaps impossible, to exhibit by experiment three substances possessing precisely or nearly the same attraction to a fourth substance. It may be easily imagined what confusion, or variation of result, would have arisen through the whole of Mr. Kirwan's inferences, if he had assumed the mineral alkali instead of the vegetable, as the foundation of his admeasurement; and still more, if calcareous earth or magnesia had been thus assumed: none of which substances, for any thing which has been alleged to the contrary, are entitled either to reception or exclusion in founding this system. It may also be observed, that the original measure of the real acids being founded upon the supposition, that marine acid air contains no water; and as this supposition can by no means be admitted since the later experiments of Dr. Priestley, from which it is rendered highly probable, that water composes a large proportion of every æriform substance; the real marine acid of Mr. Kirwan is no more a pure and determinate substance than any other marine acid of a known temperature and specific gravity.

It might perhaps be rendered probable, from the successful application of Mr. Kir-

wan's numbers to the facts of compound affinities, that the principle of the quantities dissolved might prove much more useful than Wenzel's principle of the times of the solutions, if it were not that all the deductions are vitiated by the admission of quantities of supposed real acid, the uncertainty of which prevents our discerning how far the principle is or is not applicable. It may be observed, however, that the value of this principle, whatever it may prove, must be ascertained by experiment only, and not at all by reasoning, which cannot be applied in this case: for the fundamental assertion, that the attraction of an acid to its basis is proportionate to the quantity it demands for saturation, is so far from being founded upon any argument, that it is evidently nugatory. The attraction of an acid to its basis cannot but be the same as that of the basis to the acid; because action and re-action are equal. We might therefore affirm that the attraction of magnesia to vitriolic acid is greater than that of calcareous earth to the same acid, because it requires one-fourth more of that acid for its saturation; upon the same foundation as Mr. Kirwan asserts the contrary, because a given quantity of vitriolic acid takes up more calcareous earth than it does of magnesia. And there are not wanting a sufficient number of instances of acids, weak in attractive power, which require much alkali for their saturation, or, in other words, which are taken up by alkalis in small quantities only.

I have not the least doubt but that Mr. Kirwan himself has long since perceived these objections to the theory he brought forward so long ago; and it might perhaps have appeared unnecessary to enter into any discussion of an attempt which, though not successful throughout, has procured him all the honour which his assiduity of research, and powers of investigation, are justly entitled to, if it did not seem highly probable that the numerical expressions of the powers of chemical attraction, whenever they shall be obtained, will be derived from some method dependant on the general facts he then undertook to explain. The time required to effect any change of combination, the correspondent change of temperature, of specific gravity, of consistency, fluidity, or elasticity, and the relative quantities of principles required to produce the most perfect saturation, or to produce a compound the most remote in its properties from those of the principles themselves, are among the objects which require the steady attention of those comprehensive minds which are capable of deducing remote analogies, and tracing the general laws of Nature. Mr. Kirwan is among the first who, by duly attending to these, has placed them in their true point of importance; and whoever may deduce their mutual relations in future, they will have occasion to acknowledge their obligation to his instructive works.

Thus far we have considered the means of investigating and explaining the chemical affinities or attractions; in which two leading things are required to be done, namely, the making of judicious and well-directed experiments, and the deduction of proper inferences from them. Most of the errors of chemists, and indeed of the cultivators of any science, arise from the subject being viewed in too confined a light; so that some essential object is overlooked. Nothing can be clearer than that the more simple the description or enunciation of these objects, the less the mind will be burthened, and the less probable it will be that any thing of importance will be overlooked. Hence the advantage of a concise, simple, and accurate style, which may direct the mind steadily to the subject in contemplation, without misleading by ambiguous terms, or the language of the vulgar, which is applicable to so many and such various ideas. The advantages of this are strongly felt in the mathematical sciences, where by diagrams exhibited to the eye, by terms constantly

appropriated to the expression of the same ideas, or by symbols whose quantity, value, and application vary with their relative positions, the mind is occupied with no other objects than such as tend to forward the desired investigation. This has in some degree been effected in chemical science by Geoffroy, in his first table of Simple Elective Attractions; by Bergmann, in his Symbolical Expression of the Effects of Compound Attractions; and by others, in their tables of the Component Parts of Bodies. A description of the tables contained in the ensuing pages, will sufficiently explain their nature and application.

Tables I. to VI. contain in substance the two tables of *Attractiones Electivæ Simpliciter*, placed at the end of Bergmann's Treatise upon Elective Attractions, of which a separate translation was published in London, in the year 1785. I have not made any alteration, except such as has tended to facilitate the insertion of them in their regular pages of the book, instead of adopting the much less convenient method of printing upon a large sheet, to be occasionally folded out. It will be seen therefore that I have avoided repetitions, and altered the arrangement of the columns; but have in no material respect changed the substance of the table itself, excepting that the perlate acid, vital air, the matter of heat, and siderite, are left out. The perlate acid is now well known to consist of phosphoric acid united to a certain quantity of mineral alkali; and the semi-metal siderite is known to consist of the same acid united to iron. Vital air, in the tables of Bergmann, is supposed to have an affinity to phlogiston only; and the matter of heat, which occupied a column, containing eight substances, arranged conjecturally, is left out, because of the doubt whether heat be a separate matter, or a mere modification; and also because the table of comparative heats or capacities may perhaps indicate the affinities of this substance, if it be a substance, better than any other table. (*See HEAT.*) The same reasons which induced me to retain the tables as Bergmann left them, when I published my First Principles of Chemistry, namely, that they might continue to be Bergmann's tables—and that the compilation of new tables of affinity would require a separate correspondent treatise, to ascertain the degree of dependance to which each column might be entitled—still retain their efficacy; and they are even rendered more cogent, from my observing that Mr. Morveau has thought proper to do the same in the *Encyclopédie Méthodique*.

These tables require no other explanation, than that the substances enumerated are considered to be simple, as far as relates to the facts exhibited in these sketches. The order of position denotes that the higher any substance stands in any column, the stronger is its elective attraction to the substance at the head of that column. The under part of each table exhibits the attractions in the dry way, and must be considered as entirely distinct from the upper part. The horizontal lines between the substances denote that their positions, or comparative powers of attraction, are well determined; and, whenever these lines are wanting, the positions are more or less conjectural.

T A B L E I. Simple Elective Attractions.

A C I D S.

[illegible]

In the HUMID WAY.

T A B L E III.

Simple Elective Attractions.

COMBUSTIBLE SUBSTANCES AND WATER.

IN THE HUMID WAY.				
WATER.	SULPHUR.	SALINE LIVER OF SULPHUR.	ARDENT SPIRIT.	ETHER.
Vegetable alkali	Calx of lead	Calx of gold	Water	Ardent spirit
Mineral alkali	C. of tin	C. of silver	Ether	Essential oils
Volatile alkali	C. of silver	C. of mercury	Essential oils	Expressed oils
Ardent spirit	C. of mercury	C. of arsenic	Volatile alkali	Water
Mild volatile alk.	C. of arsenic	C. of antimony	Fixed alkali	Sulphur
Glauber's salt	C. of antimony	C. of bismuth	Saline hepar	
Ether	C. of iron	C. of copper	Sulphur	
	Vegetable alkali	C. of tin		
	Volatile alkali	C. of lead		
	Barytes	C. of nickel		
	Lime	C. of cobalt	EXPRESSED OIL.	ESSENTIAL OIL.
	Magnesia	C. of manganese		
		C. of iron	Ether	Ether
Vitriolic acid			Essential oils	Ardent spirit
Vitriolated tartar	Fat Oils	Ardent spirit	Fixed alkalis	Fat oils
Alum	Essential Oils	Water	Vol. alkali	Fixed alkalis
Martial vitriol	Ether		Sulphur	Sulphur
Corrosive sublimate	Ardent spirit			
IN THE DRY WAY.				
	Fixed alkalis	Manganese		
	Iron	Iron		
	Copper	Copper		
	Tin	Tin		
	Lead	Lead		
	Silver	Silver		
	Cobalt	Gold		
	Nickel	Antimony		
	Bismuth	Cobalt		
	Antimony	Nickel		
	Mercury	Bismuth		
	Arsenic	Mercury		
		Arsenic		

TABLE IV. Simple Elective Attractions.

PHLOGISTON AND METALS.

IN THE HUMID WAY.

PHLOGISTON.	CALX OF GOLD.	C. OF SILVER.	C. OF PLATINA.	C. OF MERCURY	C. OF LEAD.
Nitrous acid	Ether	Marine acid	Ether	Acid of fat	Vitriolic acid
Vitriolic acid	Marine acid	Acid of fat	Marine acid	Marine acid	Acid of fat
Dephl. marine a	Aqua regia	Acid of fugar	Aqua regia	Acid of fugar	A. of f. of milk
Arfenical acid	Nitrous acid	Vitriolic acid	Nitrous acid	Acid of amber	A. of fugar
Phosphor. acid	Vitriolic acid	A. of f. of milk	Vitriolic acid	Arfenical acid	Arfenical acid
	Arfenical acid	Phosphor. acid	Arfenical acid	Phosphoric acid	Acid of tartar
C. platina	Sparry acid	Nitrous acid	Sparry acid	Vitriolic acid	Phosphor. acid
C. gold	Acid of tartar	Arfenical acid	Acid of tartar	A. of f. of milk	Marine acid
C. silver	Phosphor. acid	Sparry acid	Phosphor. acid	Acid of tartar	Nitrous acid
C. mercury	Acid of fat	Acid of tartar	Acid of fat	Acid of lemon	Sparry acid
C. arfenic	Pruffian acid	Acid of lemon	Acid of fugar	Nitrous acid	Acid of lemons
C. antimony		Acid of ants	Acid of lemons	Sparry acid	Acid of ants
C. bismuth		Acid of milk	Acid of ants	Acetous acid	Acid of milk
C. copper		Acetous acid	Acid of milk	Acid of borax	Acetous acid
C. tin		Acid of amber	Acetous acid	Pruffian acid	Acid of borax
C. lead		Pruffian acid	Acid of amber	Fixed air	Pruffian acid
C. nickel		Fixed air			Fixed air
C. cobalt	Fixed alkali				Fixed alkali
C. manganese	Vol. alkali	Vol. alkali			
C. iron					
C. zinc					
Water				N. B. In the antiphlogistic theory, the column intituled <i>Phlogiston</i> being taken in a reversed order, will express the elective attractions of <i>Vital Air</i> .	

IN THE DRY WAY.

	GOLD.	SILVER.	PLATINA.	MERCURY.	LEAD.
C. of platina	Mercury	Lead	Arfenic	Gold	Gold
C. gold	Copper	Copper	Gold	Silver	Silver
Acid of arfenic	Silver	Mercury	Copper	Platina	Copper
C. silver	Lead	Bismuth	Tin	Lead	Mercury
C. mercury	Bismuth	Tin	Bismuth	Tin	Bismuth
C. arfenic	Tin	Gold	Zinc	Zinc	Tin
C. antimony	Antimony	Antimony	Antimony	Bismuth	Antimony
C. bismuth	Iron	Iron	Nickel	Copper	Platina
C. copper	Platina	Manganese	Cobalt	Antimony	Arfenic
C. tin	Zinc	Zinc	Manganese	Arfenic	Zinc
C. lead	Nickel	Arfenic	Iron	Iron	Nickel
C. nickel	Arfenic	Nickel	Lead		Iron
C. cobalt	Cobalt	Platina	Silver		
C. manganese	Manganese		Mercury		
C. iron	Sa. liv. of sulph.	S. l. of sulph.	S. l. of sulphur	S. l. of sulph.	S. l. of sulphur
C. zinc		Sulphur		Sulphur	Sulphur

TABLE V. Simple Elective Attractions.

METALLIC SUBSTANCES.

IN THE HUMID WAY.					
CALX OF COPPER.	CALX OF IRON.	CALX OF TIN.	CALX OF BISMUTH.	CALX OF NICKEL.	CALX OF ARSENIC.
Acid of fugar	Acid of fugar	Acid of fat	Acid of fugar	Acid of fugar	Marine acid
Acid of tartar	Acid of tartar	Acid of tartar	Acid of arsenic	Acid of sorrel	Acid of fugar
Marine acid	Vitriolic acid	Marine acid	Acid of tartar	Marine acid	Vitriolic acid
Vitriolic acid	A. of f. of milk	Vitriolic acid	Phosphor. acid	Vitriolic acid	Nitrous acid
A. of f. of milk	Marine acid	Acid of fugar	Vitriolic acid	Acid of tartar	Acid of fat
Nitrous acid	Nitrous acid	Arfenical acid	Acid of fat	Nitrous acid	Acid of tartar
Acid of fat	Acid of fat	Phosphor. acid	Marine acid	Acid of fat	Phosphor. acid
Arfenical acid	Phosphor. acid	Nitrous acid	Nitrous acid	Phosphor. acid	Acid of sorrel
Phosphor. acid	Arfenical acid	Acid of amber	Fluor acid	Fluor acid	Fluor acid
Acid of amber	Sparry acid	Sparry acid		A. of f. of milk	A. of f. of milk
Sparry acid	Acid of amber	A. of f. of milk		Acid of amber	Acid of amber
Acid of lemon	Acid of lemons	Acid of lemons		Acid of lemon	Acid of lemon
Acid of ants	Acid of ants	Acid of ants		Acid of ants	Acid of ants
Acid of milk	Acid of milk	Acid of milk		Acid of milk	Acid of milk
Acetous acid	Acetous acid	Acetous acid		Acetous acid	Arfenical acid
Acid of borax	Acid of borax	Acid of borax		Arfenical acid	Acetous acid
Prussian acid	Prussian acid	Prussian acid		Acid of borax	
				Prussian acid	Prussian acid
Fixed air	Fixed air			Aerial acid	
Fixed alkali		Fired alkali		Volatile alkali	Volatile alkali
Vol. alkali		Vol. alkali			Unctuous oils
Fat oils					
IN THE DRY WAY.					
COPPER.	IRON.	TIN.	BISMUTH.	NICKEL.	ARSENIC.
Gold	Nickel	Zinc	Lead	Iron	Nickel
Silver	Cobalt	Mercury	Silver	Cobalt	Cobalt
Arfenic	Manganese	Copper	Gold	Arfenic	Copper
Iron	Arfenic	Antimony	Mercury	Copper	Iron
Manganese	Copper	Gold	Antimony	Gold	Silver
Zinc	Gold	Silver	Tin	Tin	Tin
Antimony	Silver	Lead	Copper	Antimony	Lead
Platina	Tin	Iron	Platina	Platina	Gold
Tin	Antimony	Manganese	Nickel	Bismuth	Platina
Lead	Platina	Nickel	Iron	Lead	Zinc
Nickel	Bismuth	Arfenic	Zinc	Silver	Antimony
Bismuth	Lead	Platina		Zinc	
Cobalt	Mercury	Bismuth			
Mercury		Cobalt			
Sol. liv. of sulph.	S. l. of fulphur	S. l. of fulphur	S. l. of fulphur	S. l. of fulphur	S. l. of fulphur
Sulphur	Sulphur	Sulphur	Sulphur	Sulphur	Sulphur

TABLE VI. Simple Elective Attractions.

METALLIC SUBSTANCES.

IN THE HUMID WAY.				
CALX OF COBALT.	CALX OF ZINC.	CALX OF ANTI-MONY.	CALX OF MANGANESE.	CALX OF WOLFRAM.
Acid of fugar	Acid of fugar	Acid of fat	Acid of fugar	Lime
Acid of forrel	Vitriolic acid	Marine acid	Acid of forrel	Vegetable alkali
Marine acid	Marine acid	Acid of fugar	Acid of lemon	Volatile alkali
Vitriolic acid	Acid of f. of milk	Vitriolic acid	Phosphoric acid	
Acid of tartar	Nitrous acid	Nitrous acid	Acid of tartar	
Nitrous acid	Acid of fat	Acid of tartar	Fluor acid	
Acid of fat	Acid of forrel	Acid of forrel	Marine acid	In the DRY WAY.
Phosphoric acid	Acid of tartar	Acid of f. of milk	Vitriolic acid	Fixed alkali
Fluor acid	Phosphoric acid	Phosphoric acid	Nitrous acid	Lime
Acid of f. of milk	Acid of lemon	Acid of lemon	Acid of f. of milk	Calx of iron
Acid of amber	Acid of amber	Acid of amber	Acid of amber	Calx of manganefe
Acid of lemon	Fluor acid	Fluor acid	Acid of fat	
Acid of milk	Arfenical acid	Arfenical acid	Arfenical acid	This column is additional. It is deduced from De Luyart's Analysis.
Acetous acid	Acid of ants	Acid of ants	Acid of ants	
Arfenical acid	Acid of milk	Acid of milk	Acid of milk	
Acid of borax	Acetous acid	Acetous acid	Acetous acid	
Pruffian acid	Acid of borax	Acid of borax	Pruffian acid	
Aerial acid	Pruffian acid	Pruffian acid	Aerial acid	
Volatile alkali	Volatile alkali			
IN THE DRY WAY.				
COBALT.	ZINC.	ANTIMONY.	MANGANESE.	WOLFRAM.
Iron	Copper	Iron	Copper	Iron
Nickel	Antimony	Copper	Iron	Silver
Arfenic	Tin	Tin	Gold	Tin
Copper	Mercury	Lead	Silver	Lead
Gold	Silver	Nickel	Tin	Antimony
Platina	Gold	Silver		Bismuth
Tin	Cobalt	Bismuth		Manganefe
Antimony	Arfenic	Zinc		Gold
Zinc	Platina	Gold		Platina
	Bismuth	Platina		
	Lead	Mercury		
	Nickle	Arfenic		
	Iron	Cobalt		
Saline liv. of fulph.		Sal. liv. of fulphur	Sal. liv. of fulphur	
Sulphur		Sulphur		

In the expression of compound affinities, it is clear, from what has already been said in this article, that these sketches must either be made from actual experiment in every instance, or by deduction from the numerical expressions of the forces of attraction. We have explained some of the difficulties which oppose the deduction of these numbers: but as a conjectural set of numbers, inferred from such facts as we possess, may be useful in many instances to point out the probability of decompositions previous to trial, I have here inserted Mr. Morveau's table of the numerical expression of affinity between the alkalis and soluble earths and the five principal acids.

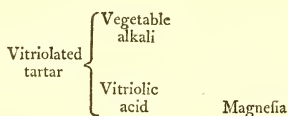
T A B L E VII.

Numerical Expression of Affinities by M. MORVEAU.

	VITRIOLIC ACID.	NITROUS ACID.	MARINE ACID.	ACETOUS ACID.	AERIAL ACID, OR FIXED AIR.
Ponderous earth	65	62	36	29	14
Vegetable alkali	62	58	32	26	9
Mineral alkali	58	50	28	25	8
Lime	54	44	20	19	12
Volatile alkali	46	38	14	20	4
Magnesia	50	40	16	17	6
Argil. earth	40	36	10	15	2

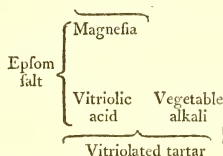
The method of exemplifying or exhibiting simple or compound affinities by symbols, according to Bergmann, consists in placing those substances which are applied to each other upon the same horizontal line of direction; the component parts of the substances being placed at the two extremities of a vertical bracket; and the new products, if any, are placed one above the other, at the middle part of an horizontal bracket, connecting their component principles. This will be rendered clearer by an example.

I. Suppose magnesia to be presented to a solution of vitriolated tartar, it will be found that no decomposition takes place. These facts are expressed as follows:



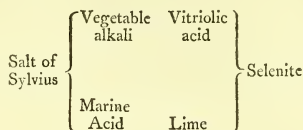
In the above scheme, the vitriolated tartar is placed opposite the point of a vertical bracket, and its two component parts, vegetable alkali and vitriolic acid, are placed within the extremities of the same bracket. Horizontally opposite the vitriolic acid is placed magnesia, to denote that it is presented to that acid. And as these two substances are not connected by a bracket, it is to be understood from the scheme that they do not unite, and consequently that the vitriolated tartar remains undecomposed.

II. On the contrary, if to a solution of Epsom salt the vegetable alkali be added, a decomposition will ensue, which is expressed as follows:



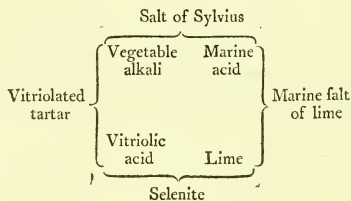
The arrangements in this scheme depend on the same principles as those of the foregoing: but the bracket underneath the vitriolic acid, and vegetable alkali, denotes that these two substances unite, and form vitriolated tartar, which is accordingly placed beneath the middle of the bracket. The point of the bracket being turned up, is made to denote that the compound remains suspended, or in solution. The magnesia is of course disengaged; and half a bracket, with the point downwards, is placed over it, to denote that it falls to the bottom, or is precipitated.

III. The above instances exhibit simple elective attractions ; but this method is more particularly applicable to the compound attractions ; for example, suppose a solution of the salt of Sylvius be added to selenite, no decomposition will take place. This is expressed as under :



The want of horizontal brackets in this scheme denotes that the principles presented to each other do not unite, and consequently that no decomposition ensues.

IV. On the contrary, if vitriolated tartar be presented to the marine salt of lime, a mutual decomposition will ensue ; thus,



In this scheme, we see that the principles presented to each other do unite, as is shewn by the horizontal brackets, and form the new compounds, salt of Sylvius and selenite ; the former of which remains in solution, as is shewn by its bracket being turned upwards ; while the latter, being nearly insoluble, falls down, and is accordingly denoted by a bracket whose point is turned downwards.

V. By attentively observing this last scheme, it may be seen that the attractions exerted between the simple substances which are placed over each other, are the quiescent affinities, and tend to preserve the original combinations ; whereas the attractions between the simple substances, which stand opposite to each other, are the divellent affinities, and tend to produce new combinations. If we were in possession of complete tables of the numerical expression of simple attraction, it is evident that we might foretel every result which might be produced by the application of compound substances to each other ; and we shall see the utility of Mr. Morveau's Table, by applying the numbers to the preceding scheme.

	Salt of Sylvius			
	Vegetable alkali	32	Marine acid	
Vitriolated tartar	62	+	20=82	Marine salt of lime
	Vitriolic acid	54	Lime	
		86		
	Selenite			

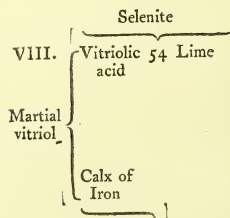
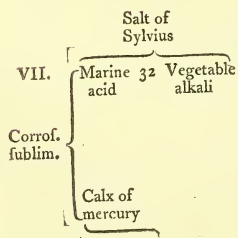
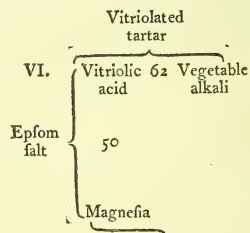
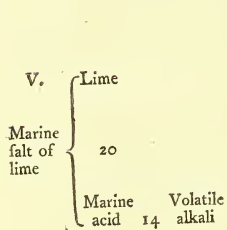
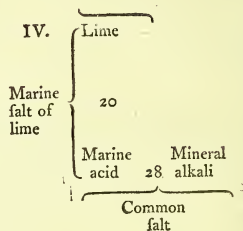
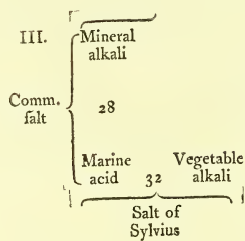
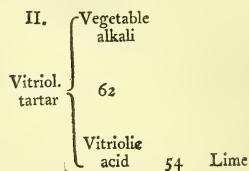
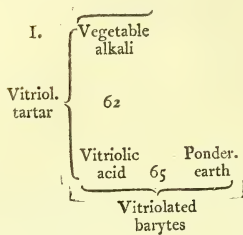
The attraction between the vegetable alkali and vitriolic acid is expressed by the number 62; and the attraction between the marine acid and lime is expressed by the number 20. These are the quiescent affinities, and their sum 82 expresses the tendency to preserve the original forms of vitriolated tartar and marine salt of lime. On the other hand, the attraction between the vegetable alkali and marine acid is expressed by 32, and the attraction between vitriolic acid and lime by 54. The sum of 32 and 54 amounts to 86, and expresses the divellent affinities which tend to produce new combinations. And as this last sum exceeds the sum of the quiescent affinities, it follows that the double decomposition will take place.

VI. In these examples we have designedly taken them the reverse of each other; but every instance, singly exhibited, does in fact point out both the affirmative and the negative propositions. Thus, from the fact first exhibited, that magnesia does not decompose the combination of vegetable alkali and vitriolic acid, it likewise follows that the vegetable alkali does decompose the combination of vitriolic acid and magnesia. And accordingly, in the two last schemes of double affinity, it is clearly ascertained, from the mutual decomposition of vitriolated tartar and marine salt of lime, that the salt of Sylvius and selenite will not decompose each other.

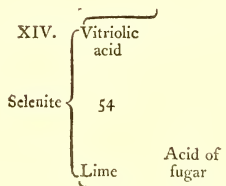
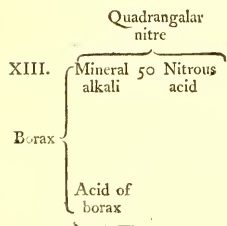
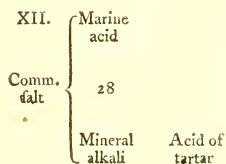
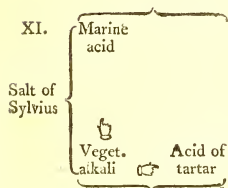
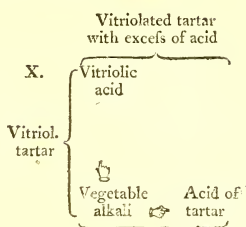
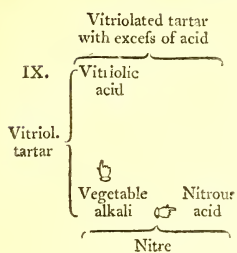
The same horizontal bracket, which in the humid way was used to denote solution, is used to denote sublimation in experiments by the dry way.

The following schemes from Bergmann will require no explanation, after the instances we have exhibited.

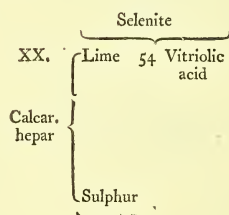
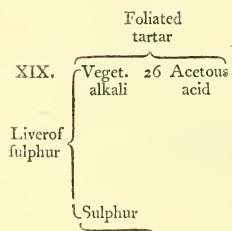
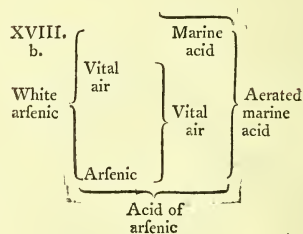
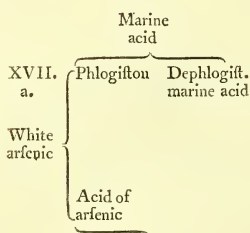
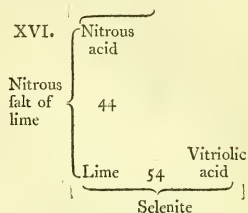
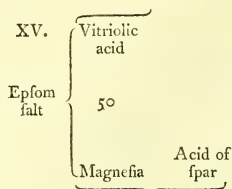
Schemes of Elective Attractions in the Humid Way.



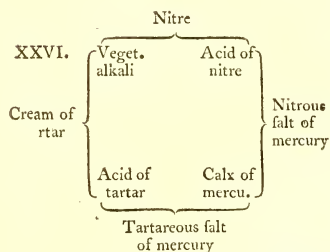
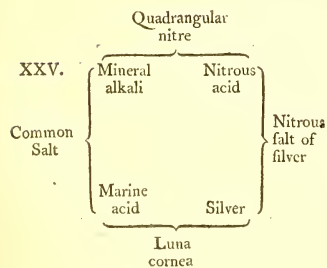
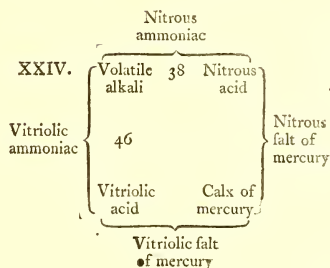
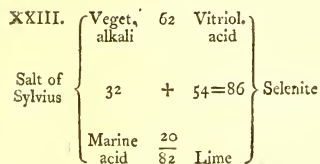
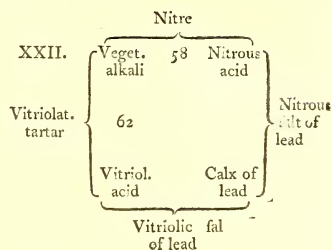
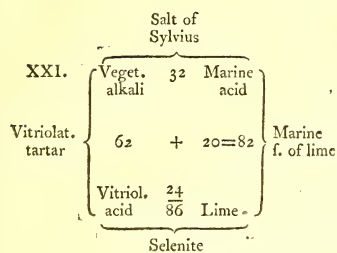
Schemes of Elective Attractions in the Humid Way.



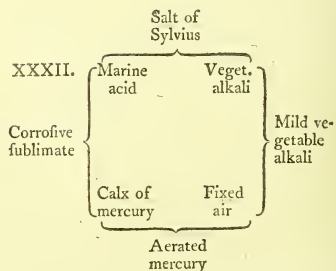
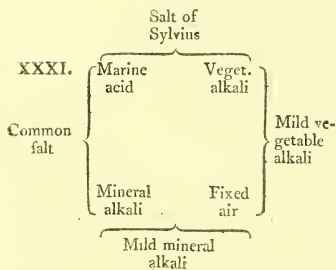
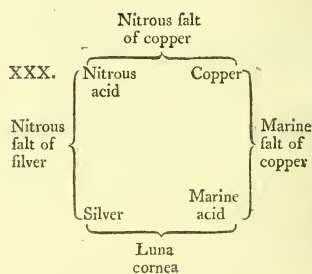
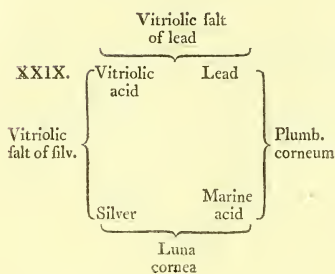
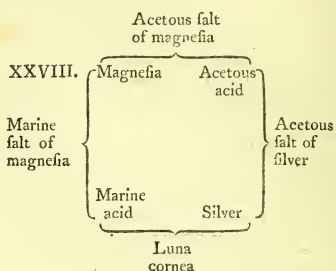
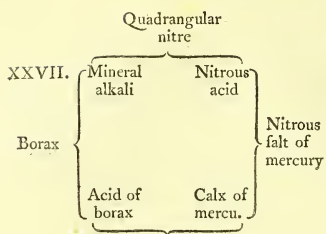
Schemes of Elective Attractions in the Humid Way.



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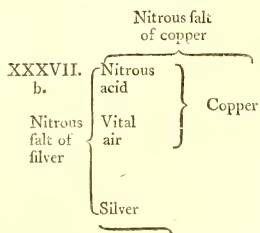
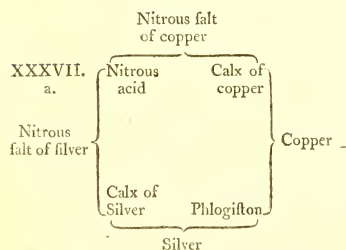
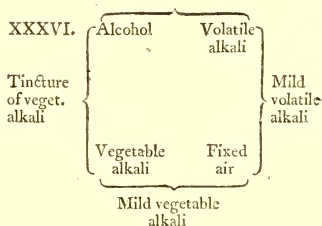
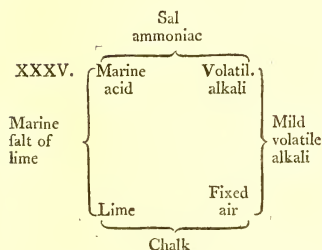
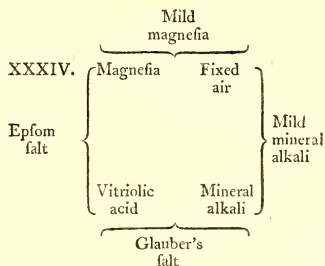
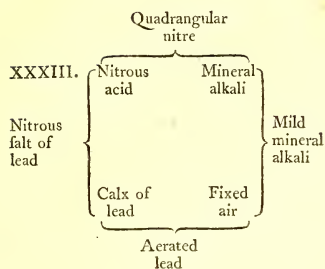


Schemes of Elective Attractions in the Humid Way.



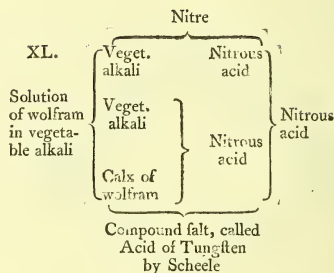
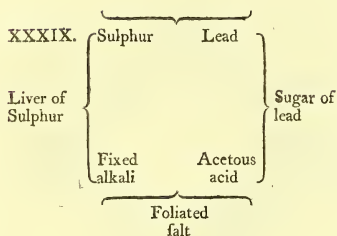
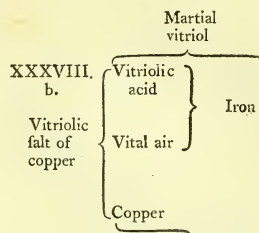
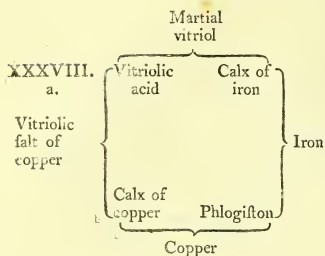
Schemes

Schemes of Elective Attractions in the Humid Way.

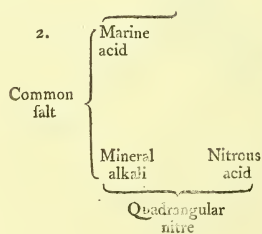
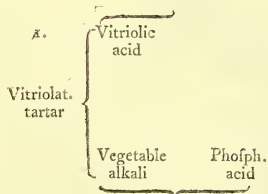


Scheme

Schemes of Elective Attractions in the Humid Way.

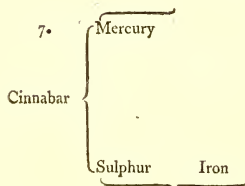
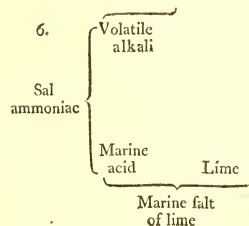
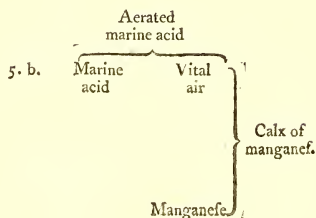
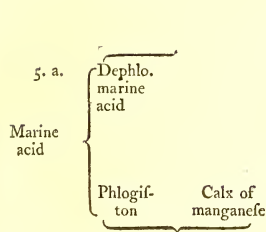
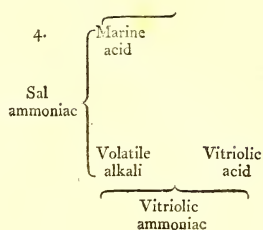
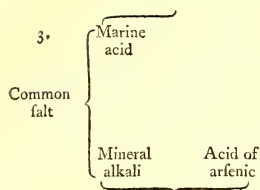


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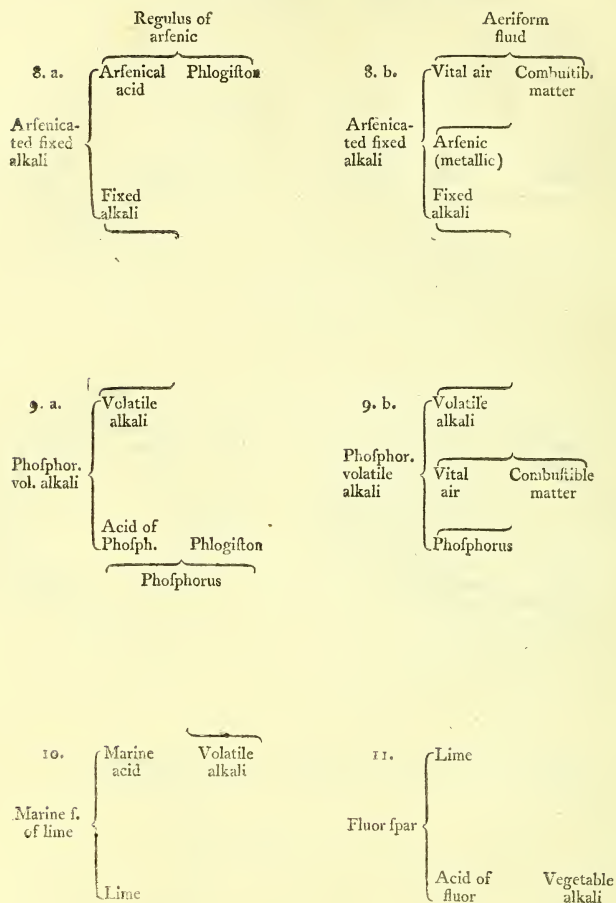
Schemes

Schemes of Elective Attractions in the Dry Way.

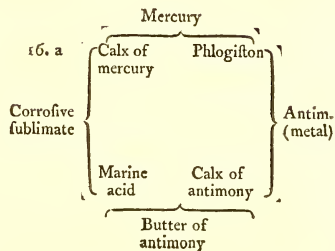
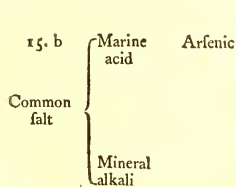
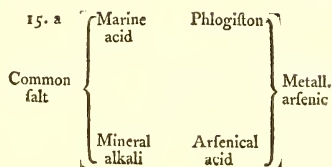
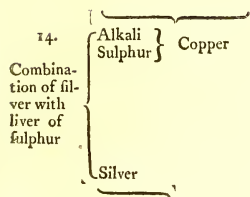
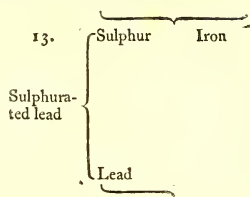
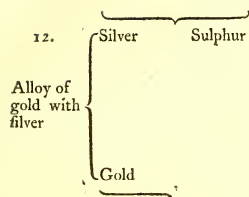


Schemes

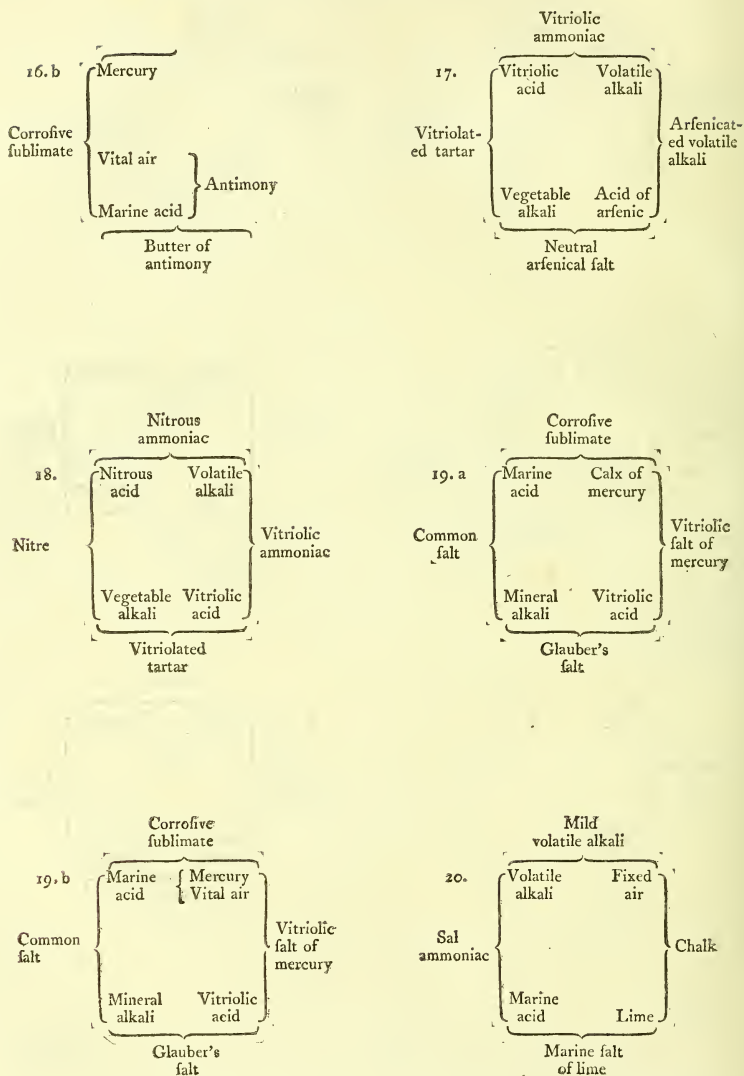
Schemes of Elective Attractions in the Dry Way.



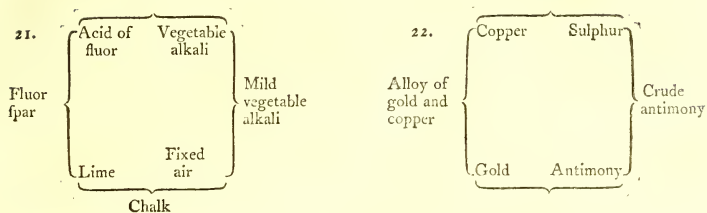
Schemes of Elective Attractions in the Dry Way.



Schemes of Elective Attractions in the Dry Way.



Schemes of Elective Attractions in the Dry Way.



I have inserted the whole of Bergmann's schemes, excepting those numbered 25, 55, and 56; the former of which includes the acid of sour, at present known to be a compound; and the two last relate to experiments with the nitrous acid, which may be considered as doubtful, because a large part of the product assumes the permanently elastic state, and has not been examined. My chief inducement for inserting all the others is, that the whole together form so considerable a body of chemical knowledge, expressed with so much perspicuity by virtue of this happy arrangement, that their value and effect cannot but greatly tend to promote the researches of experienced chemists, as well as the advancement of the learner. I speak on this occasion as if the sketches were now first published; and this, with respect to the greater number of chemical readers, is really the case: for Bergmann published them in characters; a method which is indeed attended with peculiar advantages both in the enunciation and practice of chemistry; but which never having been in general use, is very far from being familiar even to the learned. The tables have not, that I know of, been before printed in words at length. I have also inserted the numbers of Mr. Morveau, which answer as far as they can be applied; and the contemplation of those schemes which contain only partial numbers, will shew what experiments require to be made to extend them farther. Thus, in scheme 7, it is seen that the adhesion of marine acid to the calx of mercury, in the humid way, will require a less numerical expression than 32; and in scheme 8, that the attraction of vitriolic acid to calx of iron is less than 54; and the numerical expressions of these indeterminate quantities must be taken so as to agree with all the experiments known, as we have no other method of ascertaining them. The schemes numbered 18 and 37 in the humid way, and also the numbers 5, 8, 9, 17 and 19 in the dry way, shew how admirably this method is applicable to the new, as well as the old theory; and number 40, in the humid way, shews the precipitation of a triple compound. The intelligent chemist will find no difficulty in extending them to more particular cases, by attending to the rules of arrangement already described and exemplified.

AUGITES. See AQUA MARINA.

AURUM FULMINANS. See GOLD.

AURUM MUSIVUM, or MOSAICUM. A combination of tin and sulphur, which is thus made: Melt twelve ounces of tin, and add to it three ounces of mercury; triturate this amalgam with seven ounces of sulphur, and three of sal ammoniac. Put the powder into a matrafs, bedded rather deep in sand, and keep it for several hours in a gentle heat; which is afterwards to be raised, and continued

nued for several hours longer. If the heat has been moderate, and not continued too long, the golden-coloured scaly porous mass, called *Aurum Musivum*, will be found at the bottom of the vessel; but if it has been too strong, the *aurum musivum* fuses to a black mass of a striated texture. This process is thus explained: As the heat increases, the tin, by stronger affinity, seizes, and combines with, the marine acid of the sal ammoniac; while the alkali of that salt, combining with a portion of the sulphur, flies off in the form of a hepar. The combination of tin and marine acid sublimes, and is found adhering to the sides of the matrafs. The mercury, which served to divide the tin, combines with part of the sulphur, and forms cinnabar, which also sublimes; and the remaining sulphur, with the remaining tin, forms the *aurum musivum* which occupies the lower part of the vessel. It must be admitted, however, that this explanation does not indicate the reasons why such an indirect and complicated process should be required to form a simple combination of tin and sulphur.

It does not appear that the proportions of the materials require to be strictly attended to. The process of the marquis De Bullion, as described by Chaptal in his *Elements of Chemistry*, consists in amalgamating eight ounces of tin with eight ounces of mercury, and mixing this with six ounces of sulphur, and four of sal ammoniac. This mixture is to be exposed for three hours on a sand heat sufficient to render the bottom of the matrafs obscurely red-hot. But Chaptal himself found that if the matrafs containing the mixture were exposed to a naked fire, and violently heated, the mixture took fire, and a sublimate was formed in the neck of the matrafs, consisting of the most beautiful *aurum musivum* in large hexagonal plates. The marquis De Bullion obtained a good *aurum musivum* by dissolving eight ounces of tin in the muriatic acid, precipitating it by mild mineral alkali, and mixing the precipitate with four ounces of sulphur. He used this mixture instead of the foregoing, but found the *aurum musivum* unfit to increase the effects of the electric machine, as the former *aurum musivum* did, which he found to contain six parts out of seven of mercury, and to which, accordingly, he attributes the effect of electrical excitation.

Aurum musivum has no taste, though some specimens exhibit an hepatic smell. It is not soluble in water, acids, or alkaline solutions. But in the dry way it forms a yellow hepar, soluble in water. It deslagrates with nitre. Bergmann mentions a native *aurum musivum* from Siberia, containing tin, sulphur, and a small proportion of copper.

Aurum musivum is used as a pigment for giving a golden colour to small statues, or plaster figures. It is likewise said to be mixed with melted glass to imitate lapis lazuli.

AVIDITY. This term is in common use among chemists, who apply it to denote that kind of tendency to combination which exerts its effects in a short time. It does not therefore denote the power of attraction, or that by which combinations are most strongly maintained; but that modification of the attractive powers which conduces most to their speedy exertion. Thus, metallic bodies not being soluble in acids but at a certain determinate degree of calcination, and the nitrous acid being more easily decomposed or phlogificated than the marine, it is found that the nitrous acid dissolves most metallic substances with considerable rapidity, though the marine does not; but, on the other hand, the attraction of the marine acid to many of the metallic calces is such, that it takes them from the nitrous. The nitrous acid therefore is said to dissolve the metals with more avidity than

than the marine acid, notwithstanding the attraction of this last appears to be stronger.

AZURE. This term, which was formerly applied to the fine blue extracted from lapis lazuli, and at present known by the name of Ultramarine, is now more generally applied to denote the blue glass made by the combination of calx of cobalt with glass. When this is in masses, or a coarse powder, it is called Smalt. See COBALT, ULTRAMARINE.

B.

B A L

B A L

BALANCE. The beginning and end of every exact chemical process consists in weighing. With imperfect instruments this operation will be tedious and inaccurate; but with a good balance, the results will be satisfactory; and much time, which is so precious in experimental researches, will be saved.

The balance is a lever whose axis of motion is formed with an edge like that of a knife; and the two dishes at its extremities are hung upon edges of the same kind. These edges are first made sharp, and then rounded with a fine hone, or a piece of buff leather. The excellence of the instrument depends, in a great measure, on the regular form of this rounded part. When the lever is considered as a mere line, the two outer edges are called Points of Suspension, and the inner the Fulcrum. The points of suspension are supposed to be at equal distances from the fulcrum, and to be pressed with equal weights when loaded.

1. If the fulcrum be placed in the center of gravity of the beam, and the three edges lie all in the same right line, the balance will have no tendency to one position more than another, but will rest in any position it may be placed in, whether the scales be on or off, empty or loaded.

2. If the center of gravity of the beam, when level, be immediately above the fulcrum, it will overset by the smallest action; that is, the end which is lowest will descend; and it will do this with more swiftness, the higher the center of gravity, and the less the points of suspension are loaded.

3. But if the center of gravity of the beam be immediately below the fulcrum, the beam will not rest in any position but when level; and, if disturbed from that position, and then left at liberty, it will vibrate, and at last come to rest on the level. Its vibrations will be quicker, and its horizontal tendency stronger, the lower the center of gravity, and the less the weight upon the points of suspension.

4. If the fulcrum be below the line joining the points of suspension, and these be loaded, the beam will overset, unless prevented by the weight of the beam tending to produce an horizontal position, as in § 3. In this last case, small weights will equilibrate, as in § 3; a certain exact weight will rest in any position of the beam, as in § 1; and all greater weights will cause the beam to overset, as in § 2.

Many

Many scales are often made this way, and will overset with any considerable load.

5. If the fulcrum be above the line joining the points of suspension, the beam will come to the horizontal position, unless prevented by its own weight, as in § 2. If the center of gravity of the beam be nearly in the fulcrum, all the vibrations of the loaded beam will be made in times nearly equal, unless the weights be very small, when they will be slower. The vibrations of balances are quicker, and the horizontal tendency stronger, the higher the fulcrum.

6. If the arms of a balance be unequal, the weights in equipoise will be unequal in the same proportion. It is a severe check upon a workman to keep the arms equal, while he is making the other adjustments in a strong and inflexible beam.

7. The equality of the arms of a balance is of use, in scientific pursuits, chiefly in making of weights by bisection. A balance with unequal arms will weigh as accurately as another of the same workmanship with equal arms, provided the standard weight itself be first counterpoised, then taken out of the scale, and the thing to be weighed be put into the scale, and adjusted against the counterpoise; or when proportional quantities only are considered, as in chemical and in other philosophical experiments, the bodies and products under examination may be weighed against the weights, taking care always to put the weights into the same scale. For then, though the bodies may not be really equal to the weights, yet their proportions amongst each other may be the same as if they had been accurately so.

8. But though the equality of the arms may be well dispensed with, yet it is indispensably necessary that their relative lengths, whatever they may be, should continue invariable. For this purpose, it is necessary, either that the three edges be all truly parallel, or that the points of suspension and support should be always in the same part of the edge. This last requisite is the most easily obtained.

The balances made in London are usually constructed in such a manner, that the bearing parts form notches in the other parts of the edges; so that the scales being set to vibrate, all the parts naturally fall into the same bearing. The balances made in the country have the fulcrum edge straight, and confined to one constant bearing by two side plates. But the points of suspension are referred to notches in the edges, like the London balances. The balances here mentioned, which come from the country, are inclosed in a small iron japanned box; and are to be met with at the Birmingham and Sheffield warehouses, though less frequently than some years ago; because a pocket contrivance for weighing guineas and half-guineas has got possession of the market. They are, in general, well-made and adjusted, turn with the twentieth of a grain when empty, and will sensibly shew the tenth of a grain, with an ounce in each scale. Their price is from five shillings to half a guinea; but those which are under seven shillings have not their edges hardened, and consequently are not durable. This may be ascertained by the purchaser, by passing the point of a penknife across the small piece which goes through one of the end boxes; if it makes any mark or impression, the part is soft.

9. If a beam be adjusted so as to have no tendency to any one position, as in § 1, and the scales be equally loaded; then, if a small weight be added in one of the scales, that balance will turn, and the points of suspension will move with an

accelerated motion, similar to that of falling bodies, but as much slower, in proportion, very nearly, as the added weight is less than the whole weight borne by the fulcrum.

10. The stronger the tendency to an horizontal position in any balance, or the quicker its vibrations, § 3, 5, the greater additional weight will be required to cause it to turn, or incline to any given angle. No balance therefore can turn so quick as the motion deduced in § 9. Such a balance as is there described, if it were to turn with the ten thousandth part of the weight, would move at quickest ten thousand times slower than falling bodies; that is, the dish containing the weight, instead of falling through sixteen feet in a second of time, would fall through only two hundred parts of an inch, and it would require four seconds to move through one-third part of an inch: consequently, all accurate weighing must be slow. If the indexes of two balances be of equal lengths, that index which is connected with the shorter balance will move proportionally quicker than the other. Long beams are the most in request, because they are thought to have less friction: this is doubtful: but the quicker angular motion, greater strength, and less weight of a short balance, are certainly advantages.

11. Very delicate balances are not only useful in nice experiments, but are likewise much more expeditious than others in common weighing. If a pair of scales with a certain load be barely sensible to the one-tenth of a grain, it will require a considerable time to ascertain the weight to that degree of accuracy, because the turn must be observed several times over, and is very small. But if no greater accuracy were required, and scales were used which would turn with the hundredth of a grain, a tenth of a grain, more or less, would make so great a difference in the turn, that it would be seen immediately.

12. If a balance be found to turn with a certain addition, and is not moved by any smaller weight, a greater sensibility may be given to that balance, by producing a tremulous motion in its parts. Thus, if the edge of a blunt saw, a file, or other similar instrument, be drawn along any part of the case or support of a balance, it will produce a jarring, which will diminish the friction on the moving parts so much, that the turn will be evident with one-third or one fourth of the addition that would else have been required. In this way, a beam which would barely turn by the addition of one-tenth of a grain, will turn with the one-thirtieth or fortieth of a grain.

13. A balance whose horizontal tendency depends only on its own weight, as in § 3, will turn with the same addition, whatever may be the load; except so far as a greater load will produce a greater friction.

14. But a balance whose horizontal tendency depends only on the elevation of the fulcrum, as in § 5, will be less sensible the greater the load; and the addition requisite to produce an equal turn will be in proportion to the load itself.

15. In order to regulate the horizontal tendency in some beams, the fulcrum is placed below the points of suspension, as in § 4, and a sliding weight is put upon the cock or index, by means of which the center of gravity may be raised or depressed. This is an useful contrivance.

16. Weights are made by a subdivision of a standard weight. If the weight be continually halved, it will produce the common pile, which is the smallest number for weighing between its extremes, without placing any weight in the scale with the body under examination. Granulated lead is a very convenient substance to be used in this operation of halving, which however is very tedious. The readiest way to subdivide small weights, consists in weighing a certain quantity of small
wire,

wire, and afterwards cutting it into such parts, by measure, as are desired; or the wire may be wrapped close round two pins, and then cut asunder with a knife. By this means it will be divided into a great number of equal lengths, or small rings. The wire ought to be so thin, as that one of these rings may barely produce a sensible effect on the beam. If any quantity (as for example, a grain) of these rings be weighed, and the number then reckoned, the grain may be subdivided in any proportion, by dividing that number, and making the weights equal to as many of the rings as the quotient of the division denotes. Then, if 750 of the rings amounted to a grain, and it were required to divide the grain decimally, downwards, $\frac{1}{10}$ would be equal to 675 rings, $\frac{1}{100}$ would be equal to 600 rings, $\frac{1}{1000}$ to 525 rings, &c. Small weights may be made of thin leaf brass. Jewellers foil is a good material for weights below the $\frac{1}{100}$ of a grain, as low as to $\frac{1}{10000}$ grain, and all lower quantities may be either estimated by the position of the index, or shewn by actually counting the rings of wire, whose value has been determined.

17. In philosophical experiments, it will be found very convenient to admit no more than one dimension of weight. The grain is of that magnitude as to deserve the preference. With regard to the number of weights the chemist ought to be provided with, writers have differed according to their habits and views. Mathematicians have computed the least possible number with which all weights within certain limits might be ascertained; but their determination is of little use. Because, with so small a number, it must often happen that the scales will be heavily loaded with weights, on each side, put in with a view only to determine the difference between them. It is not the least possible number of weights which it is necessary an operator should buy to effect his purpose, that we ought to enquire after, but the most convenient number for ascertaining his enquiries with accuracy and expedition. The error of adjustment is the least possible, when only one weight is in the scale; that is, a single weight of five grains is twice as likely to be true, as two weights, one of three, and the other of two grains, put into the dish to supply the place of the single five; because each of these last has its own probability of error in adjustment. But, since it is as inconsistent with convenience to provide a single weight, as it would be to have a single character for every number; and as we have nine characters, which we use in rotation, to express higher values according to their position, it will be found very serviceable to make the set of weights correspond with our numerical system. This directs us to the set of weights as follows: 1000 grains, 900 g. 800 g. 700 g. 600 g. 500 g. 400 g. 300 g. 200 g. 100 g. 90 g. 80 g. 70 g. 60 g. 50 g. 40 g. 30 g. 20 g. 10 g. 9 g. 8 g. 7 g. 6 g. 5 g. 4 g. 3 g. 2 g. 1 g. $\frac{1}{10}$ g. $\frac{1}{100}$ g. $\frac{1}{1000}$ g. $\frac{1}{10000}$ g. $\frac{1}{100000}$ g. $\frac{1}{1000000}$ g. $\frac{1}{10000000}$ g. $\frac{1}{100000000}$ g. $\frac{1}{1000000000}$ g. With these the philosopher will always have the same number of weights in his scales as there are figures in the number expressing the weights in grains.

Thus 742.5 grains will be weighed by the weights 700, 40, 2, and $\frac{1}{10}$.

I shall conclude this chapter with an account of some balances I have seen or heard of, and annex a table of the correspondence of weights of different countries.

Muschenbroek, in his *Cours de Physique* (French translation, Paris, 1769), tom. ii. p. 247, says, he used an ocular balance of great accuracy, which turned (trebuchoit) with $\frac{1}{100}$ of a grain. The substances he weighed were between 200 and 300 grains. His balance therefore weighed to the $\frac{1}{100000}$ part of the whole; and would ascertain such weights truly to four places of figures.

In the *Philosophical Transactions*, vol. lxvi. p. 509, mention is made of two accurate

accurate balances of Mr. Bolton; and it is said that one would weigh a pound, and turn with the $\frac{1}{100000}$ of a grain. This, if the pound be avoirdupois, is $\frac{1}{700000}$ of the weight; and shews that the balance could be well depended on to four places of figures, and probably to five. The other weighed half an ounce, and turned with the $\frac{1}{100000}$ of a grain. This is the $\frac{1}{330000}$ of the weight.

In the same volume, page 511, a balance of Mr. Read's is mentioned, which readily turned with less than one pennyweight, when loaded with 55 pounds, before the Royal Society; but very distinctly turned with four grains, when tried more patiently. This is about the $\frac{1}{900000}$ part of the weight; and therefore this balance may be depended on to five places of figures.

Also, page 576, a balance of Mr. Whitehurst's weighs one pennyweight, and is sensibly affected with the $\frac{1}{100000}$ of a grain. This is the $\frac{1}{330000}$ part of the weight.

I have a pair of scales of the common construction, § 8, made expressly for me by a skilful workman in London. With 1200 grains in each scale, it turns with the $\frac{1}{700}$ of a grain. This is the $\frac{1}{840000}$ of the whole; and therefore about this weight may be known to five places of figures. The proportional delicacy is less in greater weights. The beam will be near a pound troy; and when the scales are empty, it is affected by the $\frac{1}{100000}$ of a grain. On the whole, it may be usefully applied to determine all weights between 100 grains and 4000 grains to four places of figures.

A balance belonging to Mr. Alchorne of the Mint, in London, is mentioned, vol. lxxvii. p. 205, of the Philosophical Transactions. It is true to 3 grains with 15lb. an end. If these were avoirdupois pounds, the weight is known to the $\frac{1}{100000}$ part, or to four places of figures, or barely five.

A balance (made by Ramsden, and turning on points instead of edges) in the possession of Dr. George Fordyce, is mentioned in the seventy-fifth volume of the Philosophical Transactions. With a load of four or five ounces, a difference of one division in the index was made by the $\frac{1}{100000}$ of a grain. This is the $\frac{1}{330000}$ part of the weight, and consequently this beam will ascertain such weights to five places of figures, besides an estimate figure.

I have seen a strong balance in the possession of my friend Mr. Magellan, of the kind mentioned in § 15, which would bear several pounds, and shewed the $\frac{1}{100000}$ of a grain, with one pound an end. This is the $\frac{1}{700000}$ of the weight, and answers to five figures. But I think it would have done more by a more patient trial than I had time to make.

The Royal Society's balance, which was lately made by Ramsden, turns on steel edges, upon planes of polished crystal. I was assured that it ascertained a weight to the seven millionth part. I was not present at this trial, which must have required great care and patience, as the point of suspension could not have moved over much more than the $\frac{1}{100000}$ of an inch in the first half minute: but, from some trials which I saw, I think it probable that it may be used in general practice to determine weights to five places and better.

From this account of balances, the student may form a proper estimate of the value of those tables of specific gravities, which are carried to five, six, and even seven places of figures, and likewise of the theoretical deductions in chemistry that depend on a supposed accuracy in weighing, which practice does not authorize. In general, where weights are given to five places of figures, the last figure is an estimate, or guess figure; and where they are carried farther, it may be taken for granted that the author deceives either intentionally, or from want of skill in reducing his weights to fractional expressions, or otherwise.

Among the numerous public exertions which our learned neighbours, the French, have made in favour of the sciences, the determination of the relative proportions of the weights used in various parts of Europe, is by no means one of the least. The most exact standard weights were procured by means of the ambassadors of France, resident in various places; and these were compared by *Monf. Tillet* with the standard mark in the pile preserved in the *Cour de Monnoies de Paris*. His experiments were made with an exact balance made to weigh one marc, and sensible to one quarter of a grain. Now, as the mark contains 18,432 quarter grains, it follows that his balance was a good one, and would exhibit proportions to four places, and a guess figure. The results are contained in the following table, extracted from *Monf. Tillet's* excellent Paper in the *Memoirs of the Royal Academy of Sciences* for the year 1767. I have added the two last columns, which shew the number of French and English grains contained in the compound quantities against which they stand. The English grains are computed to one-tenth of a grain, although the accuracy of weighing came no nearer than about two-tenths.

Table of the Weights of different Countries.

Place and Denomination of Weight.		Marc. oz.	gros. grains.	F. grains.	E. grains.
Berlin.	The marc of 16 loths	—	7 5 16	4408	3616.3
Berne.	Goldsmiths weight of 8 ounces	—	1 — 1 4	4648	3813.2
Berne.	Pound of 16 ounces, for merchandize	—	2 1 1 6	9334	8067.7
The common pound varies very considerably in other towns of the Canton.					
Berne.	Apothecaries weight of 8 ounces	—	7 5 26	4454	3654.
Bonn.	—	—	7 5 6 1/2	4398 1/2	3608.6
Brussels.	The marc, or original troyes weight	—	1 — 21	4629	3797.6
Cologn.	The marc of 16 loths	—	7 5 11	4403	3612.2
Constantinople.	The cheki, or 100 drachms	—	1 2 3 28	6004	4925.6
Copenhagen.	Goldsmiths weight, commonly supposed equal to the marc of Cologn	—	7 5 10 1/2	4438 1/2	3641.2
Copenhagen.	Merchants weight of 16 loths	—	1 — 1 22 1/2	4702 1/2	3857.9
Dantzick.	weight; commonly supposed equal to the marc of Cologn	—	7 5 3 1/2	4395 1/2	3606.
Florence.	The pound (anciently used by the Romans)	—	1 3 20	6392	5244.
Genoa.	The peso fottile	—	1 2 2 1/2 30	5970	4897.7
Genoa.	The peso grosso	—	1 2 3 5	5981	4906.7
Hamburgh.	weight; commonly supposed equal to the Cologn marc	—	7 5 7 1/2	4399 1/2	3609.4
Hamburgh.	Another weight	—	7 7 23	4559	3740.2
Liege.	The Brussels marc used; but the weight proved	—	— 24	4632	3800.1
Lisbon.	The marc, or half pound	—	7 3 1/2 3 1/2	4318	3542.4
London.	The pound troy	—	1 4 1 1/2 1	7021	5760.
London.	The pound avoirdupois	—	1 6 6 1/2 6	8538	7004.5
Lucca.	The pound	—	1 3 — 2 3 1/2	6359 1/2	5217.
Madrid.	The marc royal of Castile	—	7 4 8	4328	3550.7
Malta.	The pound	—	1 2 2 1/2 21	5961	4890.4
Manheim.	(The Cologn marc)	—	7 5 10 1/2	4402	3611.5
Milan.	The marc	—	7 5 33	4425	3630.2
Milan.	The libra grossa	—	— 7 1/2	14364 1/2	11784.
Munich.	(The Cologn marc)	—	7 5 11 1/2	4403 1/2	3612.3
Naples.	The pound of 12 ounces	—	1 2 3 1/2 27	6039	4954.3
Ratisbon.	The weight for gold: of 128 crowns	—	1 6 — 24	8088	6635.3
Ratisbon.	The weight for ducats: of 64 ducats	—	7 2 32	4208	3452.3
Ratisbon.	The marc of 8 ounces	—	1 — 24	4632	3800.1
Ratisbon.	The pound of 16 ounces	—	2 2 4 1/2 6	10693	8776.5
Rome.	The pound of 12 ounces	—	1 3 1 1/2 14	6386	5239.
Stockholm.	The pound of 2 marcs	—	1 5 7 8	8000	6603.1
Stuttgart.	(The Cologn marc)	—	7 5 11 1/2	4403 1/2	3612.6
Turin.	The marc of 8 ounces	—	1 — 22 1/2	4630 1/2	3799.
At Turin they have also a pound of 12 of the above ounces. But, in their apothecaries pound of 12 ounces, the ounce is one sixth lighter.					
Warfaw.	The pound	—	1 5 2 12	7644	6271.
Venice.	The libra grossa of 12 ounces	—	1 7 4 1/2 25 1/2	8989 1/2	7374.5
Venice.	The peso fottile of 12 ounces	—	1 1 6 1/2 24	5676	4656.5
In the pounds dependant on Venice, the pound differs considerably in each.					
Vienna.	The marc of commerce	—	1 1 1 16	5272	4325.
Vienna.	The marc of money	—	1 1 1 26	5282	4333.3
France.	The grain	—	— — —	1.	1.21895
England.	The grain	—	— — —	0.82039	1.

BALLS, MARTIAL. A medical composition, consisting of iron filings and cream of tartar, used to impregnate water, or other liquids, with iron dissolved by the acid of tartar. To make these balls, one part of filings of iron and two parts of powdered cream of tartar are mixed well together, and put into an earthen or iron vessel with some water. This mixture is to be stirred from time to time, until it becomes almost dry, and then it is to receive more water, and to be stirred as before. This treatment is to be continued until it acquires, when nearly dry, somewhat of the consistence and tenacity of softened resin. Then it is to be rolled up into the form of a ball, which is generally kept tied up in a rag; and when intended to be used, it is to be infused in water until it gives some colour to that liquid.

In this composition, part of the acid of tartar, which is redundant in the cream of tartar, combines with part of the iron; and the remaining or greater part of the cream of tartar and iron continues solid in this way of proceeding. The infusion of the martial ball in water does not therefore differ, as Macquer observes, from the tartarized tincture of iron. Its virtues are much the same as those of other martial medicines. These balls are unknown to us in England.

BALLS, MERCURIAL. These consist of an amalgam of tin and mercury, in which the former metal so far predominates, as to give the mass a solid form. Macquer mentions the use of them by travellers to purify water, in which they are boiled for this purpose. I do not see, however, in what respect they would produce any material advantage. The mercurial impregnation, which the water would slightly receive from this treatment, does not seem likely to counteract in any considerable degree the bad qualities of another nature which may predominate in waters.

BALASS, or BALAIS RUBY. A precious stone of a pale red colour, inclining to violet. It comes chiefly from the Brazils; although some likewise come from the East Indies. The value of the Balass ruby is about thirty shillings per carat, according to Dutens.

BALLOON. Receivers of a spherical form are called Balloons by the French, and likewise by several translators from that language.

BALLOON, AIR, or AEROSTATICAL. The first experiment for floating bodies in the atmosphere, by including within them a fluid specifically less heavy than common air, was made by Messrs. Stephen and John Mongolfier, at Avignon, in the month of November 1782. They raised a bag of silk, by inflating it with common air, heated or altered by combustion; it being evident that such a bag must rise on the same principle as smoke ascends from a chimney. This experiment led several French philosophers to the consideration, that inflammable air, of which the great levity had been ascertained by Mr. Cavendish in 1766, might with more permanent advantage be applied to this purpose; and accordingly M. Faujas St. Fond constructed a machine on this principle by public subscription at Paris, which was suffered to rise into the atmosphere from the Champ de Mars, in the month of August 1783. Pilatre de Rozier first ascended into the air with a balloon on Mongolfier's principle; and Messrs. Charles and Robert made the first experiment of ascending with a balloon filled with inflammable air.

Cavallo's Treatise on the History and Practice of Aerostation may be consulted for an account of the methods of constructing and filling these machines. The most usual means of obtaining the inflammable air has been to dissolve iron shavings or turnings in diluted vitriolic acid; but it appears probable that the calcination

cination of ignited iron by steam would prove the cheapest, if the demand for machines of this kind were ever to become considerable.

BALSAM. The several vegetable principles in commerce have been distinguished by various names which bear no relation to their properties, considered with regard to scientific arrangement. They have been usually considered to be oily aromatic substances, imperfectly fluid, obtained from incisions made in certain trees. Several French chemists, among whom are Fourcroy and Chaptal, have adopted the judicious distinction of Bucquet, who has confined this denomination to such resinous matters alone as possess a fragrant smell, and more especially contain acid, odorant, and concrete salts, that may be extracted by decoction or sublimation. The principal balsams, according to this division, are benzoin, balsam of Tolu or Peru, and storax, which see.

BALSAM OF SULPHUR. A solution of sulphur in oil.

All oils, whether expressed or essential, can dissolve sulphur. To make this solution, the oil must be poured on the sulphur, and sufficient heat applied to melt the substance. While the oil dissolves the sulphur, it acquires a reddish or brown colour, an acid, disagreeable taste, and a strong fetid smell, somewhat hepatic, resembling that of the combination of oil with vitriolic acid.

It is not well ascertained what happens in this combination. The fixed oils deposit sulphur in the crystallized state; but when the balsam of sulphur is distilled, the sulphur itself is totally decomposed, or at least it is no where found in a disengaged state. Homberg, by distillation with a very slow fire, obtained volatile sulphureous acid, vitriolic acid of various degrees of strength, some oil, partly fluid and partly thick, and a coaly residue, but no sulphur. From this experiment it appears, that the acid principle of the oil acidifies a certain part of the sulphur; and it is more than probable, that the inflammable air of the oil comes over in the hepatic form, in combination with another part of the sulphur.

There is some danger of explosion, when combinations of oil and sulphur are too suddenly and considerably heated.

BARYTES. See **EARTH, PONDEROUS.**

BARBADOES TAR. Petroleum, long exposed to the air, becomes converted into this substance. It is viscid, brown, black, or reddish; is not soluble in ardent spirit; easily melts, and burns with much smoke. It contains a portion of acid of amber.

BASALTES. A dark grey or black stone, generally of a ferruginous appearance externally, and crystallized in large prisms, usually hexagonal, but frequently consisting of a greater or less number of sides. From the natural history of this stone it is well ascertained to be a volcanic product, which has flowed in prodigious streams during the eruptions of burning mountains, and afterwards cracked by cooling, and perhaps by the evaporation of some volatile substance, in the same manner as clays, starch, and other substances are observed to crack. It has been a matter of controversy among various mineralogists, whether the basaltes has been formed in the humid or in the dry way. Either process is perfectly consistent with what we know of volcanic phenomena. The probability appears however to be in favour of those chemists, who suppose basaltes to owe its liquefaction to water; for although it is fusible by fire, it then forms a substance of a very different appearance from that which has been ejected from the volcanos. In this last situation it forms a black glass.

Basaltes is either found in irregular masses of all sizes, sometimes lamellated like slate, and of large dimensions, and at other times forming solid blocks. But the most

most remarkable is the columnar basalt, which forms immense masses, composed of columns, thirty, forty, or more feet in height, and of enormous thickness. These constitute some of the most astonishing scenes in nature for the immensity and regularity of their parts. The coast of Antrim in Ireland, for the space of three miles in length, exhibits a most magnificent variety of columnar cliffs; and the Giants Causeway consists of a point of that coast formed of similar columns, and projecting into the sea upon a descent for several hundred feet. These columns are, for the most part, hexagonal, and fit very accurately together, being in some instances united by a stony cement, but most frequently not adherent to each other. And the basaltic appearances on the Hebrides islands on the coast of Scotland, as described by Sir Joseph Banks, who visited them in 1772, are upon a scale still more striking for its vastness and variety.

An extensive field of enquiry is here offered to the geological philosopher in his attempts to ascertain the alterations to which the globe has been subjected. The enquiries of the chemist equally co-operate in these researches, and tend likewise to shew what useful purposes this and other substances may be applied to. Bergmann found that the component parts of various specimens of basalt were, at a medium, 52 parts siliceous, 15 pure clay, 8 chalk, or mild calcareous earth, and 25 iron. The differences seem however to be considerable; for Faujas de St. Fond gives these proportions:—46 siliceous, 30 clay, 10 lime, 6 magnesia, and 8 iron.

BASIS, or BASE. The chemical philosophers have for a long time been in the habit of considering the acids as bodies possessing an activity peculiar to themselves; and have, in general, overlooked the circumstance, that an equal activity, or power of attraction, must exist in those substances with which they combine, and are by that means deprived of their distinctive properties. The substances with which acids enter into combination, and are said to be neutralized, are for the most part less volatile than the acids themselves; and accordingly communicate a degree of fixity to those acids. From both these reasons, writers have been led to distinguish the substance which is united with any acid, by the name of the basis of the compound, or neutral salt. As a considerable advantage, with regard to chemical language, is obtained from the use of this term, which is not altogether improper, it is still much used by chemical authors. Thus, we say, salts with earthy bases, salts with alkaline bases, or salts with metallic bases, accordingly as the case may be; by which it is to be understood that these substances are united with an acid. And so, likewise, the expressions, vitriolic salt with basis of clay, nitrous salt with basis of vegetable alkali, marine salt with basis of iron, and other similar expressions, are used to advantage by chemical writers who wish to describe combinations, and at the same time to avoid the usual names which in many instances refer to theories either exploded or doubtful.

BATH. The heat communicated from bodies in combustion, must necessarily vary according to circumstances; and this variation not only influences the results of operations, but in many instances endangers the vessels, especially if they be made of glass. Among the several methods of obviating this inconvenience, one of the most usual consists in interposing a quantity of sand, or other matter, between the fire and the vessel intended to be heated. The sand bath and the water bath are most commonly used; the latter of which is called *Balneum Mariæ* by the elder chemists. A bath of steam may in some instances be found preferable to the water bath. Some chemists have proposed baths of melted lead, of tin, and of other fusible substances. These may perhaps be found advantageous in a few peculiar

peculiar operations, in which the intelligent operator must indeed be left to his own sagacity.

The water bath is nothing more than a pot or vessel containing water, which is kept boiling, and in which the digesting or distillatory vessels are kept immersed. As the heat of boiling water is nearly stationary, this temperature is found very advantageous in the distillation of essential oils, and all other substances in which an empyreumatic taint is to be feared. It may easily be imagined that the form of the bath, as well as of the vessels, may be varied according to the purposes respectively aimed at.

The sand bath consists of sand placed either in an iron pot, or upon an iron hearth with fire underneath. In this the heat is gradually communicated, although less uniformly than by the water bath; and it may likewise be carried to ignition. As the heat is greatest towards the bottom of the sand, the operator possesses a power of moderating it by raising the vessel when necessary. The extensive sand bath which is formed by spreading sand upon an iron hearth, is very useful for digestion, solution, evaporation, and other chemical processes, which may be carried on at the same time in a considerable number of vessels.

BDELLIUM. A gum resin, supposed to be of African origin. The best bdellium is of a yellowish brown, or dark brown colour, according to its age; unctuous to the touch, brittle, but soon softening, and growing tough betwixt the fingers; in some degree transparent, not unlike myrrh; of a bitterish taste, and a moderately strong smell. It does not easily take flame, and when set on fire soon goes out. In burning, it sputters a little, owing to its aqueous humidity; but cannot be said to explode, much less to explode like gunpowder, as Herman Valentini reports.

An ounce of picked bdellium, treated with water, afforded Neumann six drams two scruples of gummy extract; and afterwards, with spirit, two scruples of resin, two scruples remaining undissolved. Another scruple, treated first with rectified spirit, yielded two drams of resinous extract; and afterwards, with water, five drams two scruples of gum, only one scruple remaining undissolved. The distilled spirit has no taste or smell of the bdellium, and the distilled water very little.

BEE-GLEW. A soft unctuous glutinous matter, used by the bees for cementing the combs to the hives, and closing up the cells. Neumann seems to consider it as different from the wax; but I do not find that any experiments have been made upon it.

BEER is the wine of grain. Malt is usually made of barley. The grain is steeped for two or three days in water until it swells, becomes somewhat tender, and tinges the water of a bright reddish brown colour. The water being then drained away, the barley is spread about two feet thick upon a floor, where it heats spontaneously, and begins to grow, by first shooting out the radicle. In this state, the germination is stopped by spreading it thinner, and turning it over for two days; after which it is again made into an heap, and suffered to become sensibly hot, which usually happens in little more than a day. Lastly, it is conveyed to the kiln, where, by a gradual and low heat, it is rendered dry and crisp. This is malt; and its qualities differ according as it is more or less soaked, drained, germinated, dried, and baked. In this, as in other manufactories, the intelligent operators often make a mystery of their processes, from views of profit; and others pretend to peculiar secrets, who really possess none.

Indian corn, and probably all large grain, require to be suffered to grow into the
blade,

blade, as well as root, before it is fit to be made into malt. For this purpose, it is buried about two or three inches deep in the ground, and covered with loose earth; and in ten or twelve days it springs up. In this state, it is taken up and washed, or fanned, to clear it from its dirt; and then dried in the kiln for use.

Beer is made from malt previously ground, or cut in pieces, by a mill. This is placed in a tun, or tub with a false bottom; hot water is poured upon it, and the whole stirred about with a proper instrument. The temperature of the water in this operation, called Mashing, must not be equal to boiling; for, in that case, the malt would be converted into a paste, from which the impregnated water could not be separated. After the infusion has remained for some time upon the malt, it is drawn off, and is then distinguished by the name of Sweet Wort. By one or more subsequent infusions of water, a quantity of weaker wort is made, which is either added to the foregoing, or kept apart, according to the intention of the operator. The wort is then boiled with hops, which gives it an aromatic bitter taste, and is supposed to render it less liable to be spoiled in keeping; after which it is cooled in shallow vessels, and suffered to ferment, with the addition of a proper quantity of yeast. The fermented liquid is beer; and differs greatly in its quality, according to the nature of the grain, the mashing, the mashing, the quantity and kind of the hops and the yeast, the purity or admixtures of the water made use of, the temperature and vicissitudes of the weather, &c.

BELLY. When a metallic ore is found, not in veins, but distinct masses, these are called Bellies or Stock Works by the miners. In the iron founderies, likewise, the large air vessels which receive the air from iron bellows, worked by steam engines, and transmit it in an equal stream to the furnace by the re-action of water, are called by the workmen Regulating Bellies.

BELL-METAL. The basis of the composition called Bell-metal, is copper, which is alloyed chiefly with tin. Silver is said to be sometimes added. A small proportion of tin, added to copper, deprives it of its malleability so far as to render it quite brittle; and the specific gravity of the compound is always greater than would be deduced by computation from the quantities and specific gravities of its component parts. In certain proportions, it even exceeds that of the heavier metal. The colour of bell-metal is much whiter than might be expected from the proportion of tin which enters into its composition; and when this last metal constitutes one-third of the mass, the compound is so perfectly white, as to reflect the images of all coloured bodies without alteration, when duly polished. See **SPERMULUM**.

BEN, OIL OF. This is obtained from the ben nut, by simple pressure. It is remarkable for its not growing rancid in keeping, or at least not until it has stood for a number of years; and, on this account, it is used in extracting the aromatic principle of such odoriferous flowers as yield little or no essential oil in distillation. These preparations are made in Spain, Portugal, and more especially Italy, by the following method, according to Neumann:—Some fine carded cotton is dipped in oil, and laid in the bottom of a proper vessel: on this is spread a pretty thick layer of fresh flowers, above these some more of the dipped cotton; and thus alternately till the vessel is full. The whole is then digested, for a day and a night, in the heat of a water bath; after which the flowers are taken out, the cotton stratified in the same manner with fresh flowers, and the process repeated until the oil squeezed out from the cotton is found to be sufficiently impregnated with the odour of the subject. The digesting vessel is either of tin, with a cover to screw upon it; or of porcelain, composed of two parts, which are closely luted together. Most
of

of them have an air-hole in the top, which is stopped with a doffel of the oiled cotton, which retains such of the odorous effluvia as would otherwise make their escape. Some, instead of the oil of ben, take the ben itself, cut it in pieces, stratify it repeatedly with the flowers, and then press out its oil; but the oil thus obtained is greatly inferior in fragrance to the other.

BENJAMIN, or BENZOIN. The tree which produces benzoin is a native of the East Indies, particularly of the island Siam and Sumatra*. The juice exudes from incisions, in the form of a thick white balsam. If collected as soon as it has grown somewhat solid, it proves internally white like almonds, and hence it is called *Benzoë Amygdaloides*: if suffered to lie long exposed to the sun and air, it changes more and more to a brownish, and at last to a quite reddish brown colour. The dealers in this commodity never sell us the fine white benzoin by itself, but mix it with the inferior and fouler kinds, that one may carry off the other. Hence in the very best benzoin of the shops, we meet with pieces of various colours—white, yellowish white, yellow, brownish yellow, brown, reddish brown, and grey, all united in one lump. The dark-coloured benzoin, however, if it is free from earth and woody impurities, and from admixtures of any other resin, does not appear to be inferior in goodness to the white.

This resin is moderately hard and brittle, and yields an agreeable smell when rubbed or warmed. It is totally soluble in ardent spirit; from which, like other resins, it may be precipitated by the addition of water.

The white opake fluid thus obtained has been called *Lac Virginale*; and is still sold, with other fragrant additions, by perfumers as a cosmetic. Trituration with water separates a small quantity of the peculiar salt or acid of benzoin. See **ACID OF BENZOIN**.

BERYL. A precious stone of a blue green colour, by many authors confounded, and perhaps justly, with the aqua marine. Cronstedt however calls the lighter-coloured stone *Aqua Marine*, and the darker the *Beryl*. See **AQUA MARINE**.

BEZOAR MINERAL. This preparation is a calx of antimony, produced by distilling the nitrous acid several times to dryness from the butter of antimony, which is a combination of dephlogisticated marine acid and regulus of antimony. Much air escapes during the distillation, which may be presumed to consist chiefly of the æriform dephlogisticated marine acid, with nitrous and phlogisticated air. Experiments however are wanting. It is not probable that the remaining calx, or bezoar mineral, possesses any properties different from those of any other well-prepared calx of this semi-metal.

BISMUTH is a semi-metal of a yellowish or reddish white colour, little subject to change in the air. It is somewhat harder than lead, and is scarcely, if at all, malleable; being easily broken, and even reduced to powder, by the hammer. The internal face, or place of fracture, exhibits large shining plates, disposed in a variety of positions; thin pieces are considerably sonorous. At a temperature not exceeding the 460th degree of Fahrenheit, it melts; and its surface becomes covered with a greenish-grey or brown calx. A stronger heat ignites it, and causes it to burn with a small blue flame; at the same time that a yellowish calx, known by the name of *Flowers of Bismuth*, is driven up. This calx appears to rise in consequence of the combustion; for it is very fixed, and runs into a greenish glass

* Consult the Philosophical Transactions, vol. lxxvii. page 307, for a botanical description and drawing of the tree.

when exposed to heat alone. Bismuth urged by a strong heat in a closed vessel, sublimes entire. This semi metal crystallizes very distinctly when gradually cooled.

The vitriolic acid has a slight action upon bismuth when it is concentrated and boiling. Vitriolic acid air is exhaled, and part of the bismuth is converted into a white calx. A small portion combines with the vitriolic acid, and affords a deliquescent salt in the form of small needles.

The nitrous acid dissolves bismuth with the greatest rapidity and violence; at the same time that much heat is extricated, and a large quantity of nitrous air escapes. The solution, when saturated, affords crystals as it cools; the salt detonates weakly, and leaves a yellow calx behind, which effloresces in the air. Upon dissolving this salt in water, it renders that fluid of a milky white, and lets fall a calx of the same colour.

The nitrous solution of bismuth exhibits the same property when diluted with water, most of the metal falling down in the form of a white calx, called Magistery of Bismuth. This precipitation of the nitrous solution, by the addition of water, is the criterion by which bismuth is distinguished from all other metals. The magistery or calx is a very white and subtile powder; when prepared by the addition of a large quantity of water, it is used as a paint for the complexion, and is thought gradually to impair the skin. The liberal use of any paint for the skin seems indeed likely to do this; but there is reason to suspect, from the resemblance between the general properties of lead and bismuth, that the calx of this semi-metal may be attended with effects similar to those which the calces of lead are known to produce.

The marine acid does not readily act upon bismuth. It is necessary that the acid should be concentrated, and kept a long time in digestion upon it; or that it should be distilled from the semi-metal. The residue, when washed with water, affords a saline combination, which does not easily crystallize, but may be sublimed in the form of a soft fusible salt, called Butter of Bismuth. The marine solution of bismuth likewise affords a precipitate of calx by the addition of water. Marine acid seizes the calx of bismuth, when added to its solution in nitrous acid, and forms a compound of sparing solubility, which falls to the bottom. Alkalis likewise precipitate its calx; but not of so beautiful a white colour as that afforded by the affusion of pure water.

The effects of earths and alkalis upon bismuth, in the dry way, have been little attended to. Nitre calcines it, with scarcely any perceptible detonation. Sal ammoniac is not decomposed by bismuth in the metallic state, although its calx readily combines with the marine acid of that salt, and disengages the volatile alkali. Sulphur unites with bismuth by fusion, and forms a blueish grey brilliant mass, of a needle-formed texture.

This semi-metal unites with most metallic substances, and renders them in general more fusible. When calcined with the imperfect metals, its glass dissolves them, and produces the same effect as lead in cupellation; in which process it is even said to be preferable to lead.

Bismuth is used in the composition of pewter, in the fabrication of printers types, and in various other metallic mixtures.

It is sometimes found native; and may be analysed in the humid way by solution in nitrous acid, and precipitation by the addition of water, which throws down one hundred and thirteen grains of calx for every hundred of metallic bismuth. It is likewise found in the calciform state; and mineralized by sulphur,

of a grey colour, resembling galena, but heavier. These ores may also be analysed by nitrous acid, like the foregoing.

Bismuth is easily separable, in the dry way, from its ores, on account of its great fusibility. It is usual, in the processes at large, to throw the bismuth ore into a fire of wood; beneath which a hole is made in the ground to receive the metal, and defend it from calcination. The same process may be imitated in the small way, in the examination of the ores of this metal; nothing more being necessary than to expose it to a moderate heat in a crucible, with a quantity of reducing flux; taking care, at the same time, to perform the operation as speedily as possible, that the bismuth may be neither calcined nor volatilized.

BISTRE. A brown pigment, consisting of the finer parts of wood-foot, separated from the grosser by washing.

BITTERN. The mother water which remains after the crystallization of common or marine salt in sea water, or the water of salt springs. It abounds with Epsom salt, or the combination of vitriolic acid with magnesia, to which its bitterness is owing. See WATER (SEA).

BITUMEN. This word is used with some latitude by chemical writers. By some it is applied to such mineral substances as are of an oily nature, whether they be found in the solid or the fluid state; others apply it only to the solid inflammable substances of this kingdom, excepting only sulphur. It may perhaps be most convenient to use this term in denoting all mineral inflammable substances, found in the solid or fluid state, not coming under the denomination of earths, salts, acidifiable bases, or metallic ores. Kirwan, to whose arrangement we shall principally adhere in the present article, observes that the solid bitumens never exceed 2.5 in specific gravity. In the following short enumeration, we shall include inflammable air, hepatic air, sulphur, phosphorus, and plumbago; by which means it will exhibit a tolerably complete series of mineral inflammables. The articles themselves may be consulted for a fuller account of their respective properties. The inflammable substances found in the mineral kingdom are—

1. Inflammable air, called Fire Damp in the mines.
2. Hepatic air, which abounds in many hot-baths, in mines, and in the neighbourhood of volcanos.
3. Naptha; a fine white, thin, fragrant, colourless oil, which issues out of white, yellow, or black clays in Persia and Media. This is highly inflammable, and is decomposed by distillation. It dissolves resins, and the essential oils of thyme and lavender; but is not itself soluble either in spirit of wine or ether. It is the lightest of all the dense fluids, its specific gravity being 0.708.
4. Petroleum, which is a yellow, reddish, brown, greenish, or blackish oil, found dropping from rocks, or issuing from the earth, in the duchy of Modena, and in various other parts of Europe and Asia. This likewise is insoluble in spirits of wine, and seems to consist of naphtha, thickened by exposure to the atmosphere. It contains a portion of the acid of amber.
5. Barbadoes tar, which is a viscid, brown, or black inflammable substance, insoluble in spirit of wine, and containing the acid of amber. This appears to be the mineral oil in its third state of alteration.
6. Asphaltum is a smooth, hard, brittle, inflammable substance, which melts easily, and burns without leaving any ashes, if it be pure. It is slightly and partially acted on by spirit of wine and ether.
7. Mineral tallow, which is a white substance of the consistence of tallow, and as greasy, although more brittle. It was found in the sea on the coasts of Finland, in the year 1736; and is also met with in some rocky parts of Persia. It is near one-fifth lighter than tallow; burns with a blue flame, and a smell of grease, leaving a black viscid matter behind, which is more difficultly con-

sumed. 8. Jet, which is much harder than asphaltum; susceptible of a good polish, and glossy in its fracture. It is highly electrical, fusible in a moderate heat, and insoluble in spirit of wine. 9. Pit-coal. Of this there are many varieties; they appear to consist of petroleum, consolidated with an earth, chiefly of the argillaceous kind. 10. Peat is a black inflammable earth, which is of a viscid consistence when fresh, but hardens by exposure to the air. 11. Turf consists of mould interwoven with roots of vegetables. 12. Amber is insoluble in water, and in spirit of wine; and no other acid but the vitriolic dissolves it. By distillation, it affords a small portion of water, an oil of the nature of petroleum, and a peculiar acid. 13. Sulphur is very abundant in the mineral kingdom. 14. Phosphorus has not hitherto been found in the mineral kingdom, except in combination with lime, and some of the metals. 15. Plumbago, or black-lead.

When we attend to the inflammable substances found in the earth, or in the mineral kingdom, we may perceive that very few, and most probably none of them, can be truly said to belong to it, but have been elaborated in the bodies of animals or vegetables. From the turf that is pared from the surface of the earth, and owes its inflammability to the roots of vegetables which are mixed with it, we may descend to the peat, or black earth of the moors; in many specimens of which, vegetable remains are still perceptible; although in most they appear to be deprived of every appearance of their organic texture, their oily and inflammable nature only remaining; and from thence the transition to pit-coal is easy. For if we reflect on the vast revolutions which the earth has certainly undergone through a long course of ages, by means of which its surface has been broken, displaced, and inverted, from the actions of floods, earthquakes, and the great convulsions of nature, caused by volcanic eruptions, it will be no improbable inference that the thin although extensive strata of pit-coal, as well as the exsudations of naphtha, petroleum, and their modifications, have all arisen from the burying of extensive woody tracts of the surface, such as are common in all uncultivated countries. And this probability will be reduced to a certainty, when we advert to the natural history of pit-coal, which is met with in all the various states of transformation. Whole trees are converted into pit-coal in such quantities together, as to exhibit entire forests, in which the roots, trunks, branches, bark, and even species, are discernible. Coal pits and slate quarries exhibit innumerable marks of impressions of leaves, and other indications of their vegetable origin; and the analysis of this combustible substance tends still further to confirm this truth. On the other hand, if we attend to such instances as chemical theory might point out from the facts around us, we shall see how small the probability is, that the mineral kingdom should, after a certain limited time, contain inflammable bodies, if they were not occasionally thrown into it in consequence of the operations carried on within organized substances. For all inflammable substances tending to decompose the vital air of the atmosphere, would, in process of time, revert to the class of unflammable bodies, if the operation of the organized bodies, particularly of the vegetable kind, did not tend to disengage the vital air again, and render bodies combustible which were not so when they became parts of those substances.

BLACKNESS. Lewis, in his Philosophical Commerce of Arts, has given a history of the means of producing black colours. Since blackness, in general, is the consequence of a defect of light, any circumstance which prevents the reflection of most of the luminous rays which fall upon bodies, will cause such bodies to exhibit what is commonly called a Black Colour. Opticians have shewn that this effect

effect may arise either from the exquisite polish of bodies, which causes all the light to be reflected in one direction; or from the smallness of the primary particles, which transmit the light to the internal part of the body, instead of reflecting it. In this way, we find that all metallic substances, and likewise several other bodies, may be rendered black by mere mechanical trituration; and it is on account of the smallness of the particles that black pigments are capable of completely covering and destroying the effect of other colours. The substances described by Lewis, are—1. The black chalk of the shops, which seems to consist of an argillaceous earth, impregnated with bituminous matter, reduced to the state of coal. 2. Pit-coal, which affords a brown black, and is not easily ground to a sufficient fineness. 3. The black ferruginous sands, which are of little use as pigments. 4. Plumbago, or black lead, used for pencils. 5. Black vegetable juices; of which he enumerates the anacardium, or marking nut, from the East Indies, the juice of which stains linen or cotton of a reddish brown colour, that soon changes to a black, not to be discharged by alkalis; the Cashea nut, which affords a brownish durable stain; and various species of the toxicodendron, or poison tree, from North America, which produces a deep black permanent stain. 6. The cuttle fish ink, or black fluid contained in a peculiar vessel of that animal; but whether this ink was of considerable value for its permanency, he had no opportunity of ascertaining.

Among the blacks produced by fire, the Doctor found that the coals of wood, and of animal substances, possess various properties, according to their nature, or original texture, when used as crayons or as pigments. The foot blacks are in general much softer, and more easily unite with oils. Several of the metals, such as manganese, cobalt, and iron, are of a black colour in certain states of calcination. — On the subject of blackness, *See* INK, VARNISH, and DYING.

BLACK JACK. The miners distinguish blende, or mock lead, by this name. It is an ore of zinc, containing that metal in combination with iron and sulphur, and occasionally other ingredients.

BLACK LEAD. *See* PLUMBAGO.

BLACK WADD. One of the most remarkable ores of manganese. It is of a dark brown colour, partly in powder, and partly indurated and brittle. If half a pound of it be dried before a fire, and afterwards suffered to cool for about an hour, and then two ounces of linseed oil be gradually poured on it, mixing the whole loosely, like barm with flour, little clots will be formed: and, in something more than half an hour, the whole will grow hot, and at last burst into a flame. The temperature of the room, where this experiment was repeated, was about 30 degrees of Fahrenheit; and the heat this ore was exposed to, while drying, might be about 130 degrees.

According to Wedgwood's analysis, 100 parts of black wadd contain 43 of manganese, as much of iron, 4, 5 of lead, and near 5 of micaceous earth.

BLEACHING is the art of rendering the various kinds of thread, cloths, &c. white, by depriving them of the colour they usually possess in their original state. In this article I shall first describe the usual, or old processes*, and then proceed to the improvements which modern chemistry has made in the art.

The method of bleaching silk.—The silk, being still raw, is put into a bag of thin linen, and thrown into a vessel of boiling river water, in which has been dissolved good Genoa or Toulon soap.

* From Posslethwaite.

After the silk has boiled two or three hours in that water, the bag being frequently turned, it is taken out to beat, and is then washed in cold water. When it has been thus thoroughly washed and beaten, they wring it slightly, and put it for the second time into the boiling vessel, filled with cold water, mixed with soap and a little indigo; which gives it that blueish cast commonly observed in white silk.

When the silk is taken out of this second water, they wring it hard with a wooden peg, to press out all the water and soap; after which they shake it to untwist it, and separate the threads. Then they suspend it in a kind of stove, constructed for that purpose, where they burn sulphur; the vapour of which gives the last degree of whiteness to the silk.

The method of bleaching woollen stuffs.—There are three ways of doing this. The first is with water and soap; the second with the vapour of sulphur; and the third with chalk, indigo, and the vapour of sulphur.

Bleaching with soap and water.—After the stuffs are taken out of the fullers mill, they are put into soap and water, a little warm, in which they are again worked by the strength of the arms over a wooden bench: this finishes; giving them the whitening which the fullers mill had only begun. When they have been sufficiently worked with the hands, they are washed in clear water, and put to dry.

This method of bleaching woollen stuffs, is called the Natural Method.

Bleaching with sulphur.—They begin with washing and cleaning the stuffs thoroughly in river water; then they put them to dry upon poles or perches. When they are half dry, they stretch them out in a very close stove, in which they burn sulphur; the vapour of which, diffusing itself, adheres by degrees to the whole stuff, and gives it a fine whitening; this is commonly called Bleaching by the Flower, or Bleaching of Paris, because they use this method in that city more than any where else.

Bleaching with chalk, indigo, and sulphur.—When the stuffs have been well washed in clear water, they throw them into a bucket of cold water, containing chalk and a little indigo, wherein the stuffs are well stirred and agitated: then they take them out, and wash them again in clear water; after which they hang them on poles: when they are half dry, they put them into a stove to receive the vapour of sulphur, which finishes their perfect whitening.

This bleaching, which is not the best, though very agreeable to the eye, is called Bleaching of Beauvais; because the inhabitants of that city were the first who practised this method of bleaching woollen stuffs.

It must be observed that, when woollen stuffs have once imbibed the vapour of sulphur, it is a difficult matter to make them take a good colour in dying, unless it be a black or blue.

The manner of bleaching fine linen cloths, with the method of preparing them, as practised in Picardy, and particularly near St. Quintin.—After the linens are taken from the loom, they are put to soak in clear water for a whole day: when they have been well washed and cleaned, they are taken out, and thrown into a bucking tub filled with cold lye, made of wood ashes and water, which has been used in former processes.

When they are taken out of that lye, they are washed again in clear water, and spread in a meadow, where they are occasionally watered with clear water out of small canals, made for that purpose in the grounds. They water them with scoops, or hollow and narrow wooden peels, with a long handle.

After lying a certain time on the ground, they pass them through a fresh lye, poured

poured on hot : this lye is of different strength, according to the quality of the linens.

Being taken out of this second lye, they are washed in clear water, and laid again in the meadow ; all which several operations are repeated until the linen has acquired the desired degree of whiteness.

They are afterwards put into a weak lye, to restore the softness which the preceding strong lyes had deprived them of ; and afterwards they wash them in clear water.

They next rub them with black soap, which finishes whitening the selvages, which would never become perfectly white without the help of soap.

Then they wash them well, to take off all the soap, and put them to soak in four cows milk, the cream being first taken off. This perfects their bleaching, gives them all their softness, and makes them cast a little nap. Being taken out of the milk, they are washed again in clear water, for the last time. When they have undergone all these operations, they give them the first blue ; that is to say, they dip them into water in which a little starch has been dissolved, together with smalt, or Dutch lapis, of which the fattest and palest is the best, for the linens must not have too blue a cast.

The linens being thus bleached, after the manner we have related, the bleachers or whiteners deliver them into the hands of the merchants to whom they belong, who cause them to be properly made up.

These preparations differ according to the qualities of the linens : for there are some which ought to preserve all their strength ; and others whose strength must be diminished, in order to render them clearer.

Lawns or cambrics are prepared with starch and pale blue, or smalt diluted with clear water. They add some other drugs, the quantity and quality of which depend on the workmen's knowledge and capacity.

Being thus prepared, they are fastened with ropes to poles fixed in the ground at some distance from each other. When they are three quarters or half dry, they take them from the poles, and beat them on marble blocks, with very smooth wooden mallets, which is done to beat down the grain, and give them a more beautiful appearance.

After this, they fold them into small squares, and press them. When they come out of the press, the dealers in France put their numbers upon them, which are written or stamped upon small pieces of parchment, and tied to the selvage of the piece with silk of different colours, according to the merchant's fancy, who calls that silk his livery ; each merchant having his particular colour, which he never changes.

After this, they wrap up the pieces very neatly in brown paper of Rouen, well beat, tied with small packthread, which they commonly get from Holland. The linens are then in a proper condition to be sold, packed up, and sent to the places where they are disposed of.

All the clear linens of Picardy, such as plain, striped, or spotted lawns, are prepared after the same manner as those before mentioned ; except that these are beaten, but those of Picardy are not.

It must be observed that, the fairer the weather is, the easier are the linens bleached. In fair weather they may be bleached in a month's time ; but, in foul weather, six weeks, or more, are hardly sufficient to complete the operation.

It must also be observed, that all the linens, of whatsoever kind they be, which are bleached in Holland, Flanders, and Picardy, are dipped in cows milk
after

ater the cream is taken off; it being certain that it is this liquor which gives them that delicate whiteness so much admired in the linens which come from those different countries.

It is customary with the merchants who send their linens to the bleaching grounds of Flanders and Picardy, to mark them at each end with one or more letters of their names (which marks are made with thread of Epinay, worked with the needle); and to fasten at the places where these marks are put, some small twists, made also of the same thread of Epinay; which twists have a certain number of knots, at some distance from each other; each knot having its particular value, according as every merchant thinks proper. The marks are put, in order to know to whom each piece belongs; and the twists, to remember the prices.

The method of bleaching common linens, as it is practised in Anjou.—Immediately after the pieces are taken from the loom, they are carried to the whitster, or bleacher, who puts them directly into wooden troughs, full of cold clear water; where with wooden mallets, which are moved by a water mill, they are so well agitated and beaten, that they are insensibly cleared from all their impurities.

Being taken out of the mill, they are spread on a meadow, where the dew which they receive during a week begins to bleach them.

Then they are put into a kind of wooden tubs, when they throw over them a common lye, quite hot.

The linens having thus gone through the lye, they take them out of the tub, to clean them again in the mill; then they spread them a second time in the meadow, where they leave them a week, after which they give them a second lye: all these several operations are repeated until the linens have acquired a perfect degree of whiteness. Then they fold them up, after a manner proper to each sort, and to the places for which they are designed.

I do not find that any very considerable improvement in the whitening of silk and woollens has been lately made, excepting that it is asserted that silk may be cleared of its impurities to better advantage by the mild alkali of soda than by soaps-les, or soap; the former of which is apt to injure its texture, and the latter is expensive. It is even said that mere water will accomplish the same, especially if its vapour be confined, when heated in a vessel, upon the principle of Papin's Digester. In all probability, however, a process of this nature must require peculiar management; because the water thus confined would doubtless be as active in dissolving the silk itself, as caustic alkali might be. The remedy or precaution will consist in suffering the steam to escape through an aperture, covered by a valve, loaded with no greater weight than experiment shall shew to be sufficient for the intended purpose.

The dephlogisticated or aerated marine acid, first discovered by Scheele, has since been applied to the art of bleaching linens and cottons. Several chemists of the first eminence have attended to the properties of this substance. Mr. Berthollet has given a description of this method of bleaching in the second volume of the Annals of Chemistry, of which I shall proceed to give an abridgment.

After mentioning the experiments of Scheele, in a general way, he proceeds to relate his own experiments and observations. The first object which this philosopher proposed, was to examine the solubility in water of the oxygenated muriatic acid gas, as he calls it, according to the New Nomenclature; because he naturally imagined that, if he could obtain a solution somewhat concentrated, it would be much easier to make experiments with this liquor, than with the same substance in the

the gaseous form. He soon perceived that the gas was dissolved in water more readily, and in a much larger quantity, than the carbonic acid gas, or fixed air; and that the water, upon saturation with it, acquired a very lively smell, a yellowish colour, and peculiar characters. These first experiments were made by agitating the water in contact with this gas, in the same manner as that fluid is usually impregnated with the carbonic acid gas; but the suffocating vapour which was emitted, led him to substitute the apparatus of Mr. Woulfe instead of that he had before used. Between the retort, and the bottles filled with water for the purpose of impregnation with this gas, he placed a small bottle surrounded with ice, to retain the muriatic vapour which was not oxygenated. The bottles filled with water were likewise surrounded with ice. He observed, in this operation, that when the water became saturated with the gas, the gas itself assumed a concrete form, and was slowly precipitated to the bottom.

If a body with a recurved tube, fig. 15. C. be filled with this water, impregnated with the dephlogisticated or oxygenated muriatic acid, and the outer extremity of the tube be immersed under a receiver filled with water; if, in this situation, the fluid be exposed to the light of the sun, bubbles are soon disengaged, which pass into the receiver, and are found to consist of pure or vital air. When the bubbles have ceased to be disengaged, the liquor is found to have lost its characteristic smell, colour, and all its distinctive properties; and is found to consist of mere water, containing a proportion of common muriatic acid. This simple experiment, Mr. Berthollet observes, ought to be sufficient to afford a conviction, that the oxygenated muriatic acid is really nothing but a combination of the muriatic acid with basis of vital air, or oxigene, which is found so abundantly in the black oxide or calx of manganese; that nothing more is necessary than to urge this oxide by a strong heat, in order to obtain a large quantity. Manganese, thus treated, is no longer proper to form the oxygenated muriatic acid; because it is deprived of that portion of oxigene which is required to combine with part of the muriatic acid.

He remarks, that light possesses the property of disengaging the oxigene which was combined with the muriatic acid, by restoring that elasticity of which it was partly deprived; a restoration not to be effected by mere heat: he concludes therefore that the light combines with the oxigene, and that the elastic state of vital air is owing to this combination; which air, by losing a second time its elasticity in the process of combustion, that is to say, by a rapid combination with some other body, again suffers the principle of light to escape, at the same time that much heat is disengaged; the relation of which last substance with light is still an object for future discovery.

If vegetable colours be plunged in the oxygenated muriatic acid, they disappear more or less speedily, and more or less perfectly. When the substance under examination possesses a mixture of different colouring parts, some disappear more readily, and leave only those which more effectually resist the power of this agent, but have nevertheless suffered a considerable alteration. The yellow colouring matters usually resist the most strongly, but at length they all disappear; and when the oxygenated muriatic acid has exerted its whole action, it is found to be reduced to the state of ordinary muriatic acid. Hence it follows, that the colouring matters have deprived it of the oxigene, or vital air; and have, by this combination, acquired new properties, at the same time that they have lost that of producing colours. This ingenious chemist declines entering, in his present memoir, into the properties of these oxygenated substances; and proceeds to observe, that the oxygenated muriatic acid owes its property of destroying colours to the oxigene, which not only is com-

bined abundantly with it, but likewise adheres with very little force; and readily passes into a state of combination with such substances as have a certain degree of affinity with it. The habitudes of such a variety of colouring matters as exist in nature, with the oxigene, with light, with alkalis, and with other chemical agents, cannot but form an highly interesting, and almost entirely unexplored, part of natural philosophy.

After having observed the action which the oxygenated muriatic acid exercises in general upon colouring matter, he concluded that it might produce the same effect upon those substances which colour thread and linen, and which the art of bleaching proposes to destroy. Without confining himself to describe the process as now practised, he enters into a concise detail of the imperfect essays he made at first; a detail which will be by no means without its utility to such as are desirous of carrying the process into execution.

He at first used a very concentrated liquor, which he renewed when exhausted, until the thread or cloth appeared sufficiently white: but, in this way, he soon perceived that their texture was considerably weakened, and that they were even entirely deprived of their solidity. He therefore slightly diluted the liquor, and succeeded in bleaching his cloth, without altering it; but it soon became yellow by keeping, and more especially when it was heated, or subjected to the action of an alkaline lixivium. He directed his reflections, therefore, to the circumstances of the usual process of bleaching, which he endeavoured to imitate; because he had adopted the opinion, that the oxygenated muriatic acid ought to act in the same manner as the exposure of cloth upon bleach-grounds; which exposure alone is not sufficient for the purpose, but appears merely to dispose the colouring matter to solution in the alkali of lixivioms. He examined the dew which is precipitated from the atmosphere, and likewise that which is afforded by the nocturnal transpiration of plants; and observed that both the one and the other were saturated with oxigene to such a degree, as to destroy the colour of paper weakly tinged with turnsole; and he remarks that the ancient prejudices respecting May dew, which is the season wherein the transpiration of plants is abundant, might probably depend on some observation of this nature.

He therefore employed, alternately, the lixivioms, and the action of the oxygenated muriatic acid; by which means he obtained a permanent white. And as it is the practice, in the ordinary way of bleaching, to pass the cloth through four milk, or vitriolic acid diluted with a large quantity of water, he made the trial likewise of passing his cloths through a very diluted solution of vitriolic acid, and observed that the white was much brighter.

As soon as he had made use of the intermediatelixiviums, he found that it was not necessary to use a concentrated liquor, or to leave the cloth long in the fluid at each immersion. By this observation he avoided two inconveniences, which might have rendered the process impracticable in the large way: the first is, the suffocating smell of the fluid, which would be very inconvenient, and even highly dangerous to be repeated for a long time, and which has discouraged several operators from pursuing their attempts in this way; the second is, the danger of weakening the cloth. At this period of his experiments he likewise gave up the idea of mixing alkali with the oxygenated muriatic acid, as he had before done in most of his experiments*.

This was the state of the experiments of this excellent chemist, when he repeated

* Journal de Physique, 1785.

them in the presence of the celebrated Mr. Watt. A single glance, he observes, is sufficient to a philosopher whose abilities had been so long exercised upon the arts. Mr. Watt soon afterwards wrote to him from England, that in his first operation he had bleached five hundred pieces of cloth on the premises of Mr. Grogg, who has large bleach-grounds at Glasgow, and continues to use this new process.

In the mean time Mr. Bonjour, who had assisted Mr. Berthollet in his experiments, and who to a large share of sagacity has added a very extensive knowledge in chemistry, entered into an agreement with Mr. Constant of Valenciennes to form an establishment in that town. This project was opposed by the prejudices and interest of the bleachers, who were apprehensive of the competition of a new method. Mr. Constant could not even procure a piece of ground in the town of Valenciennes: but the Count de Belainge favoured this enterprise, and gave up a piece of ground which possessed every advantage; but, being at a certain distance from Valenciennes, would have the disadvantage of distance, if any manufactory should be established at Valenciennes itself. Mr. Bonjour had given up the well-grounded hopes which his knowledge and talents gave him reason to expect at Paris; and had in return found, in the enterprise to which he had devoted his attention, nothing but those disgusting circumstances which usually accompany new processes in the arts. He addressed himself to the Bureau de Commerce, not to reward his services, but to request that he might be defended from the disadvantages and obstacles which prejudice and an opposition of interest had created in Valenciennes, by granting to him a certain space of two leagues round Valenciennes and Cambrai, in which he alone might, during a certain number of years, exercise this new art; without constraining in any respect those who might chuse to adhere to the ancient processes, or attempt new processes, in which no use should be made of the oxygenated muriatic acid. He offered to instruct in his manufactory, in all the details of his process, all such as might be desirous of using it, and might obtain the sanction of the ministry. It is probable that, if his request had been granted, the establishment at Valenciennes might have produced a greater degree of confidence in those who had undertaken to make the necessary advances. It is probable, continues Mr. Berthollet, that they might have shortened their trials, instead of establishing the process at Courtray, as they have done; many artists might probably have been formed under the direction of Mr. Bonjour; and a great number of establishments might have been formed in the French provinces, by avoiding those fruitless trials which tend to throw discredit upon an useful art.

As soon as Mr. Berthollet had reason to hope that the process might be executed in the large way, he endeavoured to diminish the price of the liquor, by decomposing the marine salt in the very operation which served to form it. His first trials were unsuccessful; but Mr. Welter, a young and ingenious chemist to whom Mr. Berthollet had entrusted the management of the process, observed that it might be of advantage to dilute the vitriolic acid; and the operation then succeeded in the most satisfactory manner. He immediately wrote to Mr. Bonjour and Mr. Watt, the latter of whom informed him that he had made this change from the first; and the operation was long afterwards described by Mr. Chaptal, in a Memoir forwarded by him to the Academy of Sciences. Mr. Watt had likewise made use of a certain cask or butt, of a construction which Mr. Berthollet was not acquainted with; but, before this apparatus was mentioned, Mr.

Welter had constructed one, which is not only very proper to prepare the oxygenated muriatic acid, but very well calculated for several other chemical operations.

The intention of this apparatus is to multiply the surfaces of contact between the gas and the water, as it is evident that the combination can take place only at their surfaces. That part of the gas which did not enter into combination in the lower space, where it is first conveyed, passes into a second cavity or space which is above the tube intended to give it vent. The vessel which is intermediate between the pneumatic cask and the distillatory matrafs, is designed to retain that part of the muriatic acid which is not oxygenated: a small quantity of water is put into this vessel, a glass tube being plunged therein, the height of which exceeds that of the column of water the gas must overcome in the cask. The gas which passes out of the matrafs compresses the water in the intermediate vessel with a force equal to that opposed to its disengagement; so that the water rises in the tube of safety, and forms a column equal to the weight of the water which presses on the tube through which the gas enters the cask. But if, during the operation, a sudden cooling or rapid absorption of gas should take place, the water descends again in the tube, the air of the atmosphere enters, and prevents a vacuum from being formed within, which would have been attended with a reformation of the liquor, and consequently break the distilling vessel by the sudden cooling. This tube of safety, which is likewise due to the ingenious Mr. Welter*, is equally applicable to other pneumatic distillations.

If the oxide or calx of manganese be of a good kind, in small crystals, and contain very little foreign matter, the proportions which Mr. Berthollet found best calculated for distillation, are the following:

Six ounces of pulverized calx of manganese, one pound of pulverized sea salt, twelve ounces of concentrated vitriolic acid, and from eight to twelve ounces of water. If the calx of manganese contain foreign earth or metallic substances, the quantity must be augmented in proportion to its impurity. It will be known, after the operation, whether a sufficient quantity has been employed; because a small quantity ought to remain undecomposed, and of its original black colour: from this observation, the quantity proper to be used in the following operations may be ascertained.

When the calx of manganese is found to contain calcareous spar, as may be known by its effervescing upon the contact of a small quantity of vitriolic acid, it is proper to wash it before the operation with diluted vitriolic acid, to separate the calcareous part, which might be troublesome on account of the effervescence it produces: the calx must be dried after this washing.

Mr. Berthollet is of opinion, from his trials, that when the calx of manganese contains much phlogisticated air, it is scarcely proper to form the oxygenated muriatic acid: Mr. Fourcroy however asserts, that the phlogisticated air escapes in distillation from manganese by a degree of heat less than ignition, but that ignition is necessary to deprive it of its vital air. It might perhaps be found advantageous to make use of this information to purify such manganese as contains phlogisticated air, by distilling off this last aerial substance by a moderate heat before it is applied to the purpose of oxygenating the marine acid.

A greater or less quantity of water must be added, not only according to the

* Likewise thought of by the celebrated Chaptal.—See his Elements of Chemistry.

degree of the concentration of the fulphuric acid, but likewise according to the quantity of matter subjected to distillation. If this quantity be considerable, the acid must be more diluted than if it be small. It might be more advantageous to make use of an acid which had not been concentrated; because the operation of concentrating it adds to its price, and it is obliged to be again diluted with water. But Mr. Berthollet observes, that this saving can only take place when the manufactory of the vitriolic acid is near at hand; for in those situations where this acid is to be brought from a considerable distance, the expence of carriage of a greater quantity of fluid might exceed that of concentrating it.

When the materials are prepared, the calx of manganese must be carefully mixed with the sea salt, and the mixture introduced into the distillatory vessel, placed on a sand bath: the vitriolic acid must then be diluted, and suffered to cool; after which it is to be poured on the mixture, and the tube of communication between the matrass and the intermediate vessel quickly fitted in. A particular attention to the lutings is required in this operation. Mr. Chaptal takes notice, that when the vapour is perceived to escape by the smell, it is sometimes difficult to ascertain the imperfect place; but that if a feather dipped in volatile alkali be passed on such occasions over the lutes, it will shew the faulty place, by the white cloud of ammoniac formed in consequence of the combination of marine acid with the volatile alkali.

The size of the vessels ought to be such, that the matrass should be about one-third empty; and that, for the quantity here laid down, the casks should contain one hundred pints of water, with an empty space of the bulk of about ten pints; because, when the gas comes to occupy the cavities designed to receive it, the water will require a space into which it may ascend.

Before the operation is begun, the pneumatic cask must be filled. The mixture being made, the gas, which soon begins to be disengaged, first drives the atmospheric air out of the apparatus. As soon as it is apprehended that the atmospheric air has passed into the cavities, it is emptied out by means of a recurved tube, successively introduced beneath each; and in order to drive the water out which has entered into the tube, Mr. Berthollet recommends blowing strongly into it. The operation is suffered to go on without the application of heat, until it is perceived that the bubbles are more slowly emitted: at this period, a slight degree of heat is applied. It must not be strongly urged at the beginning; but by a gradual increase it is at last to be carried to ebullition, towards the end of the operation. It may be known when the operation is near its termination, by the tube of communication and intermediate vessel becoming hot.

When the gas is no longer disengaged but in small quantities, the fire is to be put out, and a sufficient time must be suffered to elapse until the matrass is nearly cold. The tube of communication may then be removed, and hot water poured in to keep the matter in solution, that it may be more easily taken out: this residue is to be poured into a large vessel, intended to preserve it for a use to be presently mentioned. The operation lasts longer in proportion to the quantity of matter. With the before-mentioned quantity, it ought to last five or six hours. It is proper not to be too much in haste, because a larger quantity of gas is by that means obtained. One single person may inspect and manage several of these apparatus, and the quantities may be much larger.

The intermediate vessel gradually becomes filled with a fluid, which consists of pure but weak muriatic acid: several operations may however be made without taking it out; but when it is apprehended that there is not a sufficient space left empty,

empty, this acid is taken out by means of a syphon : and, when its quantity is considerable enough, it may be substituted instead of the mixture of sulphuric acid and muriate of soda, in a similar operation, if it be not wanted for another use. In order that the quantity of common muriatic acid which passes out of the matrafs, may be inconsiderable, it is expedient that the first tube should make a right angle, or even a more obtuse angle, with the body of the matrafs. During the operation, it is necessary to stir the water, from time to time, by means of the agitator, in the apparatus, to favour the absorption of the gas by the water. When this is completed, the liquor is sufficiently strong to be used in bleaching. A smaller proportion of water may be put into the cask, and the fluid may afterwards be properly diluted.

In this state of concentration, though the liquor retains a considerably strong smell, yet it cannot prove noxious, or even very inconvenient, to those who use it. It is nevertheless proper to conduct it into the vessels in which the cloths are arranged by wooden channels, fitted to the opening at the lower part of the cask. It is proper to draw off the liquor from the cask as soon as it is prepared, because it acts upon the wood, and not only becomes by that means weaker, but likewise hastens the destruction of the cask : but when it is conveyed into a vessel in which cloths are properly placed, these speedily weaken it to such a degree that it does not perceptibly act upon the wood.

The cloths are to be prepared by leaving them twenty-four hours in water, or still better in the old lixivium, to extract the dressing ; after which they must be once or twice well washed in alkaline lixiviums, because all that part which can be extracted by the lixiviums would have neutralized a portion of the liquor, which requires to be carefully used. After this the cloth must be carefully washed, and disposed upon sticks in such a manner that it may be impregnated with the liquor poured on it, without any part being compressed. The framing of the sticks, as well as the cask and vessel intended to contain the cloths, ought to be constructed without iron ; because this metal becomes calcined by the oxygenated muriatic acid, and would produce iron-moulds, not to be taken out but by means of salt of forrel.

The first immersion must be longer than the following ones ; it may last three hours : after which, the cloth is to be taken out, lixiviated anew, and then put into a shallow vessel, in order that new liquor may be poured on it. It is sufficient that this immersion, and the following, should continue for the space of half an hour. The cloth is taken out, and cleared of the liquor by pressure ; then lixiviated, and subjected to new immersions. The same liquor may be used until it is exhausted ; and when it is found to be much weakened, a proportion of the liquor which has not been used may be added.

When the cloth appears white, excepting at the selvages, and a few threads darker than the rest, it must be impregnated with black soap, and strongly rubbed ; after which it is to be lixiviated for the last time, and immersed once more in the liquor.

The number of lixiviations and immersions which are necessary, cannot be determined, because it varies according to the nature of the cloth : the limits of this number, however, are between four and eight, for linen and hempen cloths. Mr. Berthollet expresses his inability to point out the best method of making the alkaline lixiviums ; this useful art being still a matter of mere practice, and variously performed in different places. It appeared advantageous to him to render the alkali caustic, by mixing one third of lime ; but in this case care must be

taken that the lixivium be strained through a cloth, in order that the calcareous earth may not mix itself with the linen, as its particles might corrode or wear it by their hardness. By this management the lixivium being rendered more active, does not require so large a quantity of alkali; and nevertheless, if the quantity of alkali be not too considerable, it produces no damage to the cloth, notwithstanding the contrary prejudice, which is very general. He has likewise remarked that it was of no advantage, and even prejudicial, that the lixiviations should be of long duration; but it is necessary that the fluid be very hot, and of considerable strength, otherwise the cloths bleached by the aerated marine acid would become coloured and ruddy when submitted to new lixiviations. This accident took place in the trials already mentioned. Cottons are much more easily and speedily bleached than linens: two lixiviums, or at most three, with the same number of immersions in the liquid, are sufficient; and as they are so much the more readily bleached, it is advantageous, when linen, hemp, and cotton are to be bleached, to reserve the liquors for the latter which have been already weakened by exerting their action on the former. Such liquors as are so exhausted as scarcely to act upon hemp or linen, will do very well for cotton.

After the last immersion in the liquor, the cloth must be plunged in four milk, or water acidulated with vitriolic acid. The true proportion is not well ascertained; but our author thinks, from his experiments, that one part of the acid by weight, with fifty parts of water, may be employed successfully, and without danger. The cloths are to be kept about half an hour in this fluid, warmed; after which, they must be strongly pressed, or wrung, and immediately plunged in common water: for, if they were suffered to dry by evaporation, the vitriolic acid, becoming concentrated, would attack them. When the cloths are well washed, nothing more is necessary than to dry and prepare them in the usual manner.

It is an obvious precaution, that this acid water be not too strong, as it would of course injure the texture of the stuffs.

Fig. 1. Pl. II. exhibits the apparatus for preparing the liquid intended to be used in this new method of bleaching. A B C is a furnace; c is the matrafs, or distillatory vessel; G H I the tube of communication with K, the intermediate vessel; L the tube of safety; M a tube communicating with the tub N, the section of which tub is exhibited in fig. 2, while the lower orifice of this tube is seen at y. In the tub N are fixed three inverted vessels, open beneath, as represented in fig. 3, and intended to contain the aeriform marine acid. P P P are agitators for the purpose of stirring the water by the rotation of the upright post O Q. The effect of this apparatus may be easily understood, by considering that the aeriform dephlogisticated marine acid, issuing from the tube y, passes into the vessel X, until it has excluded the water it may contain: after which the surplus issues through the tube Z, and runs into the second vessel; which, becoming also filled, affords its surplus to the third, or uppermost vessel. Hence it follows, that three surfaces of the water are exposed to an atmosphere of dephlogisticated marine acid; and these surfaces must of course be changed by the rotation of the agitators. In this manner the water becomes impregnated, and may be drawn off at P. It is of consequence to ascertain its relative strength, in order that the experiments may at all times be equally successful. Mr. de Croifille makes use of a solution of indigo in the vitriolic acid; for which purpose he takes one part of finely-pulverized indigo, with eight parts of concentrated vitriolic acid. This mixture is kept in a matrafs for several hours on the water bath; and, when the solution is complete, it is diluted with a thousand parts of water. In order to ascertain the force of the
 oxide-

oxygenated muriatic acid, one measure of this solution is put into a graduated tube of glass, and the liquor or impregnated water is added, until the colour of the indigo is completely destroyed. In this way it is ascertained, by means of the graduations, how many measures of any liquor, whose goodness has been ascertained by direct experiments upon linen or cotton, are necessary to destroy the colour of one measure of the solution of indigo; and this number will serve to ascertain the respective force of all the liquors which are required to be compared together. Mr. Watt makes use of a solution of cochineal for the same purpose.

In the sixth volume of the *Annals of Chemistry*, Mr. Berthollet has published some additions to the foregoing Memoir, which, on account of its extensive utility, I have scarcely at all shortened. They are the following:—Mr. Welter finds that it is advantageous to terminate the process by exposing the thread or cloth for three or four days in the field; during which they must be occasionally watered, and afterwards washed with pure water. He considers this exposition as indispensable. But Mr. Berthollet observes, that other persons have bleached to the perfect satisfaction of artists without it; though he admits that it may happen, in the large way, that certain pieces may not turn out perfectly white after the last operation, in consequence of some of their parts having suffered casual pressure; and he thinks that, although a continuance of the operation would remove these imperfections, it might, in such cases, prove more advantageous to remove them by exposure on the grass; very little loss of time, and no considerable extent of premises, being required for this purpose.

Mr. de Croixville has excluded the use of wood in every part of his apparatus; and has applied the process not only to bleaching, but to the discharging of colours in dyed cottons or linens.

Mr. Berthollet further observes, that the precaution of plunging the cottons in pure water, after they have been taken out of the acidulated water, is not sufficient; but it is necessary to plunge them into a weak caustic lixivium, moderately heated, and keep them there for a short time.

When the liquor is suffered to run immediately into the troughs, care must be taken to mix it well with the agitator; because otherwise the most saturated liquor, which occupies the lower part of the vessel, running first, would exert too strong an action; or if half or three quarters of the liquor be drawn off, and mixed with the proper quantity of water, according to the precautions before established, the rest of the fluid may be used together with the water for the succeeding operation: lastly, he observes that this process, simple as it is, can scarcely be carried into execution, without, in the first instances, being directed by a person to whom the operations of chemistry are familiar. He observes that a diminution, or even an equality of the expences, relative to the ordinary process, is not to be hoped for, excepting for the bleaching of fine cloths, unless the operator possesses a good process to extract the soda from the residue of the distillation; and without this condition the bleaching of coarser cloths ought not to be undertaken, excepting in those cases wherein the advantages arising from the speed of the operation, the facility of performing it in all places and at all times, and the diminution of the stock or capital, are sufficient to compensate for the excess of the price. These observations are perhaps applicable to linens, and not cottons. It is not possible, he continues to observe, to lay down principles applicable to every particular case; but he advises those who may undertake this object, to begin by trials, and by means of those trials to form calculations, without any allowance on the favourable side. On the other hand, he advises the operator not to suffer himself to be imposed

imposed on by those losses which arise for want of being familiarized with the operations; as there is no great expence incurred by making trials for a time, by which this advantage is derived, that the operator renders himself more expert for carrying more extensive processes into effect.

BLENDE. An ore of zinc, likewise known by the name of Mock Lead, False Galena, or Black Jack. There are several varieties of this ore. In general, they contain about half their weight of zinc, about one fourth sulphur, and the rest iron, copper, lead, and some earth in varied proportions.

BLOOD. The fluid which first presents itself to observation when the parts of living animals are divided or destroyed, is the blood, which circulates with considerable velocity through vessels, called Veins and Arteries, distributed into every part of the system. It can scarcely admit of doubt, that the component parts, or immediate principles, of the blood must differ in the various and exceedingly dissimilar genera and species of animals which occupy the land and waters of the globe; and that there are likewise differences in the state or composition of this fluid in the same animal according to its state of health, as well as the situation of the vessels from which it may be extracted. These differences can be ascertained only by the united efforts of the anatomist and the chemist. But as the difficulty and extent of the subject have hitherto prevented any considerable progress, it becomes an object of necessity to confine our attention to the blood of man, or of such quadrupeds as afford this fluid in a state not obviously different from that of the human species.

Recent blood is uniformly fluid, and of a saline or slightly ferruginous taste. Under the microscope, it appears to be composed of a prodigious number of red globules, swimming in a transparent fluid. After standing for a short time, its parts separate into a thick red matter, or crassamentum, and a fluid called Serum. If it be agitated till cold, it continues fluid; but a consistent polypous matter adheres to the stirrer, which by repeated ablutions with water becomes white, and has a fibrous appearance: the crassamentum becomes white and fibrous by the same treatment. If blood be received from the vein in warm water, a similar filamentous matter subsides, while the other parts are dissolved. Alkalis prevent the blood from coagulating; acids, on the contrary, accelerate that effect. In the latter case, the fluid is found to contain neutral salts, consisting of the acid itself, united with mineral alkali, which consequently must exist in the blood, probably in a disengaged state. Ardent spirit coagulates blood. On the water bath, blood affords an aqueous fluid, neither acid nor alkaline, but of a faint smell, and easily becoming putrid. A stronger heat gradually dries it, and at the same time reduces it to a mass of about one-eighth of its original weight. In this state it slightly attracts the humidity of the air, and effervesces with acids; but by a longer exposure for some months it becomes covered with an efflorescence of mild mineral alkali. By destructive distillation, this animal fluid affords a watery liquor, holding in solution a neutral salt with excess of volatile alkali, but whose acid part has not been well ascertained: next follow a light oil, a dense coloured oil, and foul or oleaginous volatile alkali. The residue is a coal of a very different incineration, containing common salt, mineral alkali, and an earth, which is probably a combination of lime and phosphoric acid.

The serum of blood exhibits marks of a disengaged alkaline salt, and is greatly disposed to putrefy. It unites with water in all proportions, and forms a milky fluid, which may be coagulated by acids, or ardent spirit. An increase of temperature causes serum to become consistent, with little or no loss of weight, in the same manner as

the white of egg ; and it is accordingly used for the same purpose in clarifying liquids. From a variety of experiments, it appears highly probable that white of egg, serum of blood, and the pure curd of milk do not essentially differ from each other : and to these we may perhaps add the vegetable gluten, which considerably resembles cheese.

Alkalis render the serum of blood more fluid : acids coagulate it, and exhibit the neutral salt they would have produced by combination with mineral alkali. The coagulum affords, by distillation, phlegm, mild volatile alkali, and a thick fetid oil ; and the residue affords mild mineral alkali. These products are the same as are afforded by the serum itself.

Serum is coagulated by ardent spirit, merely by the loss of part of its water. When rendered concrete by heat, and exposed to the action of nitrous acid, it affords phlogisticated air by a slight heat, which is followed by nitrous air ; and the residue affords acid of sugar, together with a small portion of acid of apples.

The crassamentum of blood, when treated in the way of destructive distillation, becomes dry and brittle, at the same time that it emits an alkaline phlegm : this is followed by an empyreumatic stinking oil, and concrete volatile alkali. A spongy brilliant coal remains, which by treatment with vitriolic acid is found to contain mineral alkali and iron, as appears by the production of Glauber's salt and martial vitriol : coaly matter and phosphorated lime are then left behind.

The fibrous matter which is obtained by washing the red part of the blood, resembles the serum in many of its properties ; though it differs from it in not being soluble in water, in becoming hard by a very gentle heat, and in not combining with alkalis. Acids unite with it, and in particular the nitrous acid dissolves it, and extricates phlogisticated and nitrous air ; while the residue, by evaporation, affords acid of sugar in crystals, a peculiar oil in flocks, and the phosphoric salt of lime. Its volatile products, by destructive distillation, are nearly the same as those of serum : but its residue contains no salt, except the combination of lime and phosphoric acid ; the other salts it might have contained having probably been carried off during the washing. Marine acid forms a green jelly with the fibrous part of the blood.

Blood contains much iron. The experiments of Menghini, Bucquet, and Lorry prove that the metal is capable of passing into the blood by the first passages, since patients who are under a course of martial medicine void it by the way of urine. When the coagulated part of the blood has been washed, if that part which has retained the colouring matter be burned, and the coal be lixiviated, the residue of this lixivium is in the state of saffron of Mars, of a fine colour, and usually obedient to the magnet.

The colour of blood has been attributed to this iron ; and it is very true that the colour appears to be entirely formed of it ; for there exists no vestige of this metal in the washed and discoloured coagulum : but as, on the other hand, the blood does not become coloured without the concurrence of air, and as vital air alone is absorbed in respiration, it appears that the colour is owing to iron calcined by the pure air, and reduced to the state of red calx.

BLOW-PIPE. This useful instrument has been already described under the article APPARATUS, which see. The present article will therefore consist of an account of the materials, or subjects, upon which experiments are made with this instrument. The bodies intended to be heated by the blow-pipe must not in general exceed the size of a pepper-corn, unless bellows and very large flame be used. The proper supports are either a piece of smooth close-grained charcoal, for such
bodies

bodies as are not subject to such an alteration of their properties, from the inflammability of the coal, as might be contrary to the nature of the investigation. This support is therefore most frequently used ; as it is properly adapted for saline, earthy, and many metallic bodies. The other support consists of a spoon, somewhat less than a quarter of an inch in diameter, made of a metal not subject to calcination ; that is to say, pure gold, silver, or platina, or such a mixture of these metals as might be found to be least deficient in the requisite degree of hardness, which gold or silver alone does not possess. Bergmann advised to add one-tenth of platina to a given mass of silver. I find, however, that this mixture, with picked grains of crude platina, forms a compound harder indeed than pure silver, but subject to blister at a low red heat, and perhaps more fusible than silver itself. There is, however, no very considerable inconvenience resulting from the use of a small spoon, either of gold, or of silver ; and platina, purified to such a degree as to be perfectly malleable, and to exceed 21,0 in specific gravity, possesses every quality which can be wished for. The small metallic spoon must of course be properly fixed in a socket of metal, provided with a wooden handle.

Very small or pulverulent substances are apt to be carried away by the current of flame. These may be secured by making a small hole in the charcoal, in which the powder is to be put, and covered with another small piece of charcoal, which partly protects them from the flame. Some experiments of reduction are made by binding two small pieces of charcoal together, cut in a channel along the piece intended to be the undermost, and making a cavity in the middle of this channel to contain the subject matter of examination. With this apparatus the flame is urged through the channel between the two pieces of coal, and violently heats the substance in the cavity, which may be considered as a closed vessel.

A great number of mineral bodies are not fusible by mere flame, urged by common air through the blow-pipe ; though dephlogisticated or vital air subdues most bodies.

Whenever therefore the fusion of any refractory substance is to be attempted, some other substance must be added which is more fusible, and capable of dissolving the former. These solvents in the dry way are distinguished by the name of Fluxes, and, like the solvents used in the humid way, are mostly saline. It may easily be imagined, that the nature of the products will greatly vary, according to that of the flux which enters into combination with them ; and accordingly they are varied in experiments, as well as in operations in the large way. The blow-pipe experiments, though conducted upon the same principles as those upon a larger scale, differ nevertheless from them in two particulars ; namely, that the whole of the phenomena are visible throughout, and that the residues are of no value, otherwise than as they serve to indicate facts. For these reasons, every flux without exception might be used with the blow-pipe, provided it were not of such a nature as to sink into the charcoal. We may therefore select a certain small number of the most convenient fluxes, and note the effects which they respectively produce upon the various mineral bodies ; and these will serve as indications to enable the chemical enquirer to distinguish them again with a much greater degree of accuracy than by their external figures, not to mention that he may also derive the greatest advantage with regard to the more extensive operations he might be disposed to undertake. A considerable part of this preliminary labour has already been performed by Engestrom, Bergmann, Mongez, and others ; and it is now become usual for chemists, among their other experiments on minerals, to mention their

habitudes with the blow-pipe. In the following general sketch, I shall chiefly recur to Bergmann's Treatise on the Blow-pipe, of which we have an English translation in the second volume of his Essays. A good Treatise on this subject by Engeström may likewise be consulted at the end of the English edition of Cronstedt's Mineralogy; and the habitudes of a very great number of bodies with the blow-pipe may be seen in the French edition of Bergmann's *Sciagraphia Regni Mineralis*, by the abbé Mongez, under the title of *Manuel du Minéralogiste*.

The fluxes which have obtained the general sanction of chemists, on account of the extensive use they have been applied to by Bergmann, are :

1. The phosphoric acid, or rather the microcosmic salt, as it is generally called, which contains that acid, partly saturated with mineral, partly with volatile alkali, and loaded besides with much water and a gelatinous fat. This salt, when exposed to the flame, boils and foams violently with a continual crackling noise, until the water and volatile alkali have flown off : afterwards it is less agitated, sending forth somewhat like black scoriæ, arising from the burned gelatinous part : these are soon dispelled, and exhibit a pellucid sphærule, encompassed by a beautiful green cloud, which is occasioned by the deflagration of the phosphorus arising from the extrication of the acid by means of the inflammable matter.

The clear globule which remains upon the removal of the flame, continues longer soft than that formed by borax, and therefore is more fit for the addition of the matter to be dissolved. The volatile alkali is expelled by the fire, and leaves an excess of acid, which easily attracts moisture in a cool place.

2. The mineral alkali, or sal sodæ, which, when fused upon charcoal, melts superficially with a crackling noise, penetrates the charcoal, and disappears. This, in the spoon, yields a permanent sphærule, so long as it is kept fluid by the blue apex of the flame ; but when the heat is diminished, it assumes a milky opacity, and cannot be employed upon charcoal. This alkali attacks several substances, particularly siliceous matters.

3. Crystallized borax, exposed to the flame upon charcoal, at first becomes opake, white, and wonderfully intumescent ; it throws out branches and various protuberances : but when the water is expelled, it is easily collected into a mass, which, when well fused, yields a colourless sphærule, and retains its transparency even after cooling : if calcined borax be employed, the clear sphærule is more speedily obtained. This salt consists of a mineral alkali, partially saturated with a peculiar acid, known by the name of Sedative Salt ; each of its principles is separately fusible, and each dissolves a great number of other matters.

The habits of these salts, when exposed to fire, being once known, it will be easy to understand the differences occasioned by the different additions.

The habitudes of the salts, according to Bergmann, are as follows :

The acid of arsenic in the dry state, when urged by the blow-pipe upon charcoal, becomes so far reduced as to regenerate white arsenic, and emit the smell of garlic. In the spoon it fuses, and does not smoke, unless by a partial reduction from the flame, or the metallic support.

The acid of molybdena, when exposed to the flame upon charcoal, is absorbed.

Alkalis. The crystallized vegetable alkali first becomes opake, and decrepitates long and violently, then melts into a globule, which persists in the spoon, but expands on the charcoal, and is absorbed with a crackling noise.

The mineral alkali has the same properties as the sal sodæ, already described.

The volatile alkali liquefies a little, and is dissipated.

Neutral Salts. Several of the neutral salts flow twice ; but, according to their different

different natures, they exhibit different phenomena, which a few examples will sufficiently illustrate.

The Decrepitating Salts. These are broken and dispersed by sudden heat: of this sort are vitriolated vegetable and volatile alkali, salited vegetable and mineral alkali.

Volatile Salts, which have a base totally volatile, and generally fly off; vitriolated, nitrated, and salited volatile alkali.

Genuine Salt of Amber, by the exterior flame on the charcoal, liquefies and smokes; by the interior takes fire, and in burning disappears with a blue flame.

In the spoon the same happens, except when the salt abounds with oil, which almost always happens; in this case, some coaly vestiges remain. The spurious salt of amber differs according to the frauds used in its preparation; it generally, in the beginning, swells, smokes, and grows black, then white, and finally melts into a fixed white mass.

Detonating Salts. These salts, which always abound with nitrous acid, liquefy in the spoon, and persist even on the charcoal, unless it takes fire; for when ignited, they immediately take fire on the contact of phlogiston, sending forth a violent flame with a detonating noise. During this operation, the acid is diffipated, and the basis, if fixed, remains alone. If the base be volatile, scarce any detonation is excited; for the salt flies totally off.

Nitrated vegetable alkali shews a blue flame; but the nitrated mineral and volatile alkali, a yellow one.

Carbonaceous Salts. These, by the combustion of their acid, yield spongy coals, which when ignited soon grow white, leaving behind the alkaline base: such are, acid of tartar, crude tartar, sal acetosellæ, and tartarized vegetable and mineral alkali.

Hepatiscent Salts. These, exposed to the flame on the charcoal, flow, and yield a yellow or red mass, which diffuses an hepatic smell, especially when moistened by any acid. To this class belong all those fixed in the fire, containing vitriolic acid, which, when saturated with the phlogiston of the charcoal, generate sulphur: these are, vitriolated vegetable and mineral alkali.

Middle Earthy Salts. Of the middle earthy salts, few flow so perfectly as to be reduced to a globule; nor do they all fuse actually, though the water of crystallization in its departure excites a foam: those which contain vitriolic acid effervesce violently with borax and microcosmic salt, but are difficultly dissolved by sal sodæ.

Decrepitating Earthy Salts. Gypsum spathosum.

Intumescient Earthy Salts. Vitriolated magnesia swells, foams, and, when repeatedly exposed to the flame, may be fused.

Alum is somewhat different; for finally all ebullition ceases, and the mass remains immovably at rest, and it undergoes no other change than to split: when hot, it is variegated with blue spots.

Acetated lime swells much like alum, but scarcely adheres to the charcoal.

Nitrated magnesia swells with a crackling noise, but without any detonation.

Salited magnesia, in a dry state, belongs to this class.

Fusible Salts. Although gypsum eluded the force of fire in Pott's furnace, yet it may be fused in a moment if a section of the lamella be exposed in the blue flame: though naturally pellucid, it instantly acquires an opacity; the water goes off without ebullition.

Carbo-

Carbonaceous Earthy Salts. Tartarized lime and magnesia: nay, all the earths united with acid of tartar.

Soluble in borax and microcosmic salt, with effervescence. Lime, magnesia, vitriolated clay, and acetated lime.

Middle Metallic Salts. Some of the middle metallic salts, either containing a large quantity of water, or retaining pertinaciously the acid, flow in the fire; others only foam: most of them recover, at least partly, their metallic appearance, especially when they touch the coal, leaving at the same time an irregular scoria. By the addition of borax, the scorise are dissolved, and the regulus better collected; but here we consider the salts alone: the fluxes are tinged in the same way as by the metal calxes.

Decrepitating Metallic Salts. Nitrated lead, tartarized antimony.

Volatile Metallic Salts. To this belong the salts whose base is mercury, as they are dissipated by fire: those which contain marine acid, in general, fly off more quickly than those which are loaded by any other menstruum.

Detonating Metallic Salts. Silver, mercury, lead and bismuth, united with nitrous acid.

Intumescent Metallic Salts. At the first approach of fire they swell with noise, and a certain ebullition, but then remain immovable. Vitriolated and nitrated copper, iron and cobalt vitriolated, vitriolated and nitrated zinc.

Fusible Metallic Salts. These are by the exterior flame easily reducible to globules. By this method, silver and lead, salited in the spoon, put on the corneous appearance; but by a long violent fusion they again put it off, the acid being too much diminished: hence it appears with what caution these metals are to be made horny in the crucible. Silver and lead vitriolated, copper and zinc salited.

Carbonaceous Metallic Salt. Tartarized antimony.

Metallic Salts tinging the flame. Vitriolated copper, and also nitrated copper, produce a greenness; but salited copper acts with far more efficacy. The green crystals of this first grow red by the exterior flame; they soon liquefy and grow black; they make the flame at first of a deep blue, which afterwards verges to a green. The flame, thus tinged, expands much, and remains so until the whole mass of the salt is dissipated: this green salt, added to microcosmic salt in fusion, immediately shews a beautiful flame; the clear globule is tinged green, and does not grow opaque or brown, unless a large quantity of the microcosmic salt be added; a circumstance which takes place much sooner upon the addition of a smaller quantity of borax.

Habitudes of the Primitive Earths.

Lime.

This (which by itself is infusible), by a sufficient degree of heat, loses its property of effervescing in acids; it acquires solubility in water, the power of generating heat with it, and of suffering spontaneous calcination. These last properties, however, it loses, if too much urged by heat. The heat it generates with water, may easily be tried by a drop of water on the back of the hand, with the addition of a small piece of lime, just cooled after burning.

Crude calcareous earth effervesces a little with mineral alkali, and is divided into small particles, but sparingly dissolved: when overburned, it seems not to be divided or diminished.

In

In borax the former dissolves with effervescence; the latter scarcely generates any bubbles.

In microcosmic salt the same phenomena appear; but the effervescence is somewhat greater.

It is also observable, that a very small piece of calcareous earth is easily dissolved in borax and microcosmic salt, yielding sphaerules altogether pellucid: but if more earth be gradually added, the flux, at length saturated, retains the dissolved matter, indeed, while in perfect fusion; but on removing the flame, the part which was taken up by means of the heat alone, separates; from hence clouds arise at first, and the whole globule becomes opaque, and recovers its transparency again by fusion. This is entirely correspondent to what happens in the humid way: for warm water saturated with nitre, or Glauber's salt, upon cooling, is obliged to deposit that part which it had taken up in virtue of its warmth. If the fused pellucid globule (which would grow opaque upon cooling) be quickly plunged into melting tallow, water, or any other substance hot (for cold generally cracks it), so as to grow suddenly hard, it retains its transparency; the particles being as it were fixed into that state which is necessary to transparency. This is a phenomenon highly worthy of observation, which cannot be seen in the crucible.

Terra Ponderosa.

Terra ponderosa, exposed alone to the flame, becomes like calcareous earth, caustic, soluble in water, and non-effervescent in acids.

In sal sodæ it effervesces only a little, but is sensibly diminished.

In borax it dissolves with slight effervescence; as also in microcosmic salt; but here it effervesces somewhat more violently.

The phenomena observed on saturation with calcareous earth have place here also: magnesia ignited alone loses its aerial acid, together with the property of effervescing in acids; in sal sodæ it effervesces a little, but is scarcely diminished.

Clay.

Common argillaceous earth abounds with heterogeneous particles, and always contains a considerable quantity of siliceous earth, which generally amounts to half; hence, when clay is required pure, as in this instance, the earth of alum, digested in an alkaline lixivium and well washed, must be employed.

Exposed to the flame, it grows hard, contracts its bulk, but does not fuse.

In sal sodæ it effervesces a little, but is sparingly dissolved.

In borax it dissolves with remarkable effervescence.

In microcosmic salt, a still more violent ebullition takes place.

Siliceous Earth.

Alone it is not fused.

Sal sodæ dissolves it with violent effervescence; and if the siliceous earth dissolved exceeds the weight of the flux, it yields a pellucid glass. This, and all the other operations with sal sodæ, must be performed in the spoon.

In borax it dissolves slowly, without any ebullition; in microcosmic salt, very slowly, and without effervescence.

Derivative Earths.

To avoid confusion from multiplicity, we shall collect these into classes, according to their most remarkable habits.

Decrepitating.

Spathose mineral fluor. Lapis ponderosus*. Calcareous spar. Spathum ponderosum. The decrepitation may be performed without scattering in a glass tube, closed by the finger, and held over the flame.

Infusible.

Diamond. Pure asbestos †. Refractory clay †. Hyacinth. Hydrophanous siliceous jasper. Lapis ponderosus. Pura mica †. Quartz. Ruby. Sapphire. Flint. Steatite †. Topaz.

Those four marked with a † are indurated by fire.

Infusible, changing colour.

Bolar earths generally grow black; lime mixed with aerated magnesia, black; lime blackened by subtil bitumen, white.

Of the gems, some change or lose colour; these are the crysolith, topaz, and sometimes the sapphire.

The red and green jasper acquire a whitish or grey colour.

Green, black, and red steatite grow white.

Fusible without ebullition.

Martial asbestos. Augites (aqua marina †). Basaltes. § Crysolith †. Mineral fluor. Granite. Marga. Petrofalex. Emerald †. Spathum ponderosum. (This corrodes the charcoal, and acquires an hepatic taste.) Spathum pyromachum. Trapp.

The earths marked with a † do not but with great difficulty shew any signs of fusion.

Fusible with ebullition.

Lithomarga. Schoerl-§. Turmalin. The inflated scoria quickly grows white, though the stone is brown. Zeolith.

Fusible altogether in sal sodæ, and with effervescence.

Achates. Chalcedony. Cornelian. Cos Turcica †. Mineral fluor †. Onix; Opal. Quartz. Common flint. Spathum ponderosum.

These marked † effervesce but little.

* This is the name given by Mr. Cronstedt (§ 209) to a fossil, which he enumerates among the ores of iron, and which possesses a peculiar specific gravity. Scheele, Bergmann, and De Luyart have examined it, and found it to consist chiefly of lime and a peculiar acid. This stone is now better known by its Swedish name *TUNGSTEN*; which see, and also its acid.

§ The yellowish crystalline matter which fills up the interstices of the native Siberian iron exhibit the same properties with respect to fire as the crysolith.

|| Bergmann uses the words Schoerl and Trapp, which are now known all over Europe. By basaltes he understands larger prisms, which compose the Giant's Causeway, Staffa, and other columnar mountains.

Divisible with or without effervescence in *sal sodæ*, but not entirely soluble.
 Amianthus. Asbestos. Basaltes. Crysolite. Garnet †. Hornblende.
 Jasper. Lapis ponderosus. Lithomarga. Mica. Matrix of the alum of Tol-
 fa. Petrofalex. Aluminous schist. Tegular schist, or roof slate of Helsing. Eme-
 rald. Spathum pyromachum. Steatites. Talc. Trapp. Trippel. Tourmalin.

Not fusible, or divisible by *sal sodæ*.

Diamond. Hyacinth. Ruby. Sapphire. Topaz.

Soluble in borax, with more or less effervescence.

Mineral fluor †. Marga. Mica †. Ore of Tolfa. Aluminous schist. Te-
 gular schist of Helsing † (Roof Slate). Spathum ponderosum. Schoerl. Talc.
 Tourmalin.

Those marked † effervesce but little.

Soluble in borax, without effervescence.

Agate. Diamond. Amianthus. Asbestos. Basaltes. Chalcedony. Cor-
 nelian. Crysolite. Cos Turcica. Garnet. Hyacinth. Hydrophanous siliceous
 jasper. Lapis ponderosus. (The flux grows hardly blue; on too much cooling
 it becomes white and opaque.) Lithomarga. Onyx. Opal. Petrofalex. Quartz †.
 Ruby. Sapphire. Common flint †. Emerald. Steatites. Spathum pyroma-
 chum. Trapp. Trippel. Topaz †. Zeolite.

Those marked † require a greater quantity of flux and longer heat than the
 rest.

Soluble in microcosmic salt, with more or less effervescence.

Basaltes †. Cos Turcica. Mineral fluor †. Lapis ponderosus. It efferves-
 ces at first, then scarcely dissolves: the flux acquires a fine blue tinge, without
 any mixture of redness. The colour is discharged by the exterior flame, or by a
 small quantity of nitre; but is restored by the interior flame: if the proportion
 of earth be large, it acquires a pellucid brown colour, not dischargeable either
 by nitre or the flame; if still larger, it grows black and opaque. Marble. Mica †.
 Aluminous ore of Tolfa. Aluminous schistus. Tegular schistus of Helsing †.
 Schoerl. Spathum ponderosum. Tourmalin.

Those marked † effervesce but little.

Soluble in microcosmic salt, without effervescence.

Agate. Diamond. Amianthus. Asbestos. Chalcedony †. Cornelian †.
 Crysolith †. Granite. Hornblende. Hyacinth. Hydrophanous siliceous
 jasper †. Lithomarga. Onyx †. Opal †. Petrofalex. Quartz †. Ruby.
 Sapphire. Common flint. Emerald. Steatites. Spathum pyromachum. Talc.
 Topaz. Trapp. Trippel. Zeolite.

Those marked † are more difficultly dissolved than the rest, and scarce sen-
 sibly.

In general it is to be observed, 1. That when the effervescence is to be exa-
 mined, only a very small piece of the matter is to be added to the flux, as the most
 subtil powder contains air, which being expelled by the heat, forms the ap-
 pearance of effervescence. 2. That the solution is often accelerated by lime,
 spathum ponderosum, gypsum, and other additaments, both in borax and micro-
 cosmic salt. 3. That gypsum alone is sometimes an excellent and very useful

flux. This salt, with an equal portion of fluor mineral, is easily reduced to a pelucid globule, which yet upon cooling grows white and opaque. The spathum ponderosum also unites with mineral fluor, but the mass does not become pelucid.

BLUE, PRUSSIAN. A combination of iron with a substance of the nature of an acid, and distinguished by the name of the *acid of Prussian blue*; which see.

A casual circumstance occasioned the discovery of this pigment. Diesbach, a chemist of Berlin, being desirous of precipitating a decoction of cochineal with fixed alkali, borrowed a quantity of alkali of Dippel, from which he had several times distilled his animal oil; and as the decoction of cochineal contained martial vitriol, a beautiful blue precipitate fell down. An account of Prussian blue was given in the Memoirs of the Academy of Berlin, in the year 1710, but with no intimation of the process. It was afterwards rendered public by Woodward, in the Philosophical Transactions, who declared that he had received it from one of his friends in Germany.

To make Prussian blue, four ounces of alkali are mixed with an equal weight of dried bullock's blood, and the mixture is exposed to ignition in a covered crucible. By this treatment a coal is obtained, which is afterwards lixiviated in water, filtered, and concentrated by evaporation. The liquor is known by the name of the Phlogificated Alkali. On the other hand, two ounces of martial vitriol and four ounces of alum are dissolved in a pint of water. The two solutions are then mixed, and a blueish deposition falls down, which is rendered still more intensely blue by washing it with marine acid.

This is the process used in chemical laboratories; but another method is followed in the manufactories. The raspings of horns, clippings of skins, or other animal substances, are converted into charcoal, by heating them in covered vessels. Thirty pounds of potash are then mixed with ten pounds of this coal, and the mixture calcined in an iron vessel. After twelve hours ignition, the mixture acquires the form of a soft paste, which is poured out into vessels of water. The water is then filtered, and the solution mixed with another, consisting of three parts of alum, and one of martial vitriol.

Various theories have been exhibited respecting Prussian blue by Geoffroy, Macquer, Sage, and others, in which considerable ingenuity is displayed relative to the state of chemical knowledge at the time they were exhibited: but the discoveries of Scheele and Berthollet have afforded us much light with respect to the analysis of this substance, for which consult the article last referred to.

BLUE, SAXON. The best Saxon blue colour may be given by the following composition:

Mix one ounce of the best powdered indigo with four ounces of oil of vitriol, in a glass body or matrafs, and digest it for one hour with the heat of boiling water, shaking the mixture at different times: then add twelve ounces of water to it, and stir the whole well, and, when grown cold, filter it. This produces a very rich deep colour. If a paler blue be required, it may be obtained by the addition of more water. The heat of boiling water is sufficient for this operation, and can never spoil the colour: whereas a sand heat, which is commonly used, is often found to damage the colour. Indigo which has been digested with a large quantity of spirit of wine, and then dried, will produce a finer colour than the former, if treated in the same manner with oil of vitriol.

BOG ORES. These are ores of iron, consisting of a calx of the metal in
a state

a state of greater or less purity, mixed with earth chiefly of the argillaceous kind. They appear to have been deposited by water, and are usually disposed in strata, separated into small prismatic parts by the contraction of the clay.

The chief of these are, theatrites, or eagle-stone, with other round pieces or pebbles; and the hæmatites, or blood-stone.—*See IRON.*

BOLE. Various indurated clays have been distinguished by this name, which was formerly much used: but, as it has been very little noticed, as a term, by the later improvers of mineralogical and chemical science, its present signification is very indeterminate.

BOLOGNIAN STONE. Lemery * reports, that an Italian shoemaker, named Vincenzo Casciarolo, first discovered the phosphoric property of the Bolognian stone. It is the ponderous spar, or combination of vitriolic acid with ponderous earth. This man found it at the foot of mount Paterno; and, from its brilliancy and weight, was led to suppose that it contained silver. Having exposed it to the fire, doubtless with the intention of discovering that precious metal, he observed that it was luminous in the dark; a discovery which engaged his attention, and was frequently repeated with success. Many philosophers and chemists have since examined this phenomenon, and have varied the method of calcining the Bolognian stone in many respects. It seems as if the greatest degree of phosphorescence depended on a due application of the heat; but many trivial circumstances were noticed by the earlier chemists, which in all probability had little to do in producing this effect. An extreme degree of heat fuses this stone.

BONE. The bones of men and quadrupeds owe their great firmness and solidity to a considerable portion of the phosphoric salt of lime which they contain. When these are rasped small, and boiled in water, they afford gelatinous matter, and a portion of fat or oil which occupied their interstices. By destructive distillation they afford alkaline phlegm, a fetid oil, and much volatile alkali, leaving a coal not easily burned. In an open fire, bones are inflamed by virtue of their oil, and emit an offensive empyreumatic smell. The white, friable, and incombustible residue consists chiefly of lime and phosphoric acid in combination. It affords a small quantity of mild mineral alkali by washing with water. This white matter is decomposable by fusion with mild fixed alkalis, which unite with the phosphoric acid, at the same time that the fixed air converts the lime into chalk. Acids likewise disengage the phosphoric acid by uniting with the lime. The nitrous or the vitriolic acids are most commonly used in this process.

BORAX. The origin of borax was for a long time unknown in Europe; and many chemists still continue to copy from each other that its origin has not yet been ascertained. Mr. Grill Abrahamson, however, sent some to Sweden in the year 1772, in a crystalline form, as dug out of the earth in Thibet, where it is called Pounnxa, Myypoun, and Houipoun: it is said to have been also found in Saxony in some coal pits †. But the most particular accounts we possess concerning the origin of borax, are found in the Philosophical Transactions for 1787. Mr. Blane, who had an opportunity of enquiring of some of the inhabitants of the place where the borax is made, gives the following account:

This saline substance, called in the language of the country Swagah, is brought into Hindostan from the mountains of Thibet. The place where it is produced, is in the kingdom of Jumlate, distant from Betowle about thirty days

* Course of Chemistry, translated by Keill, page 709.

† Kirwan's Mineralogy, 206.

journey north. Jumlate is the largest of the kingdoms in that part of the Thibet mountains, and is considered as holding a superiority over all the rest.

The place where the borax is produced, is described to be in a small valley surrounded with snowy mountains, in which is a lake about six miles in circumference, the water of which is constantly hot, so much so that the hand cannot be held in it for any time. The ground round the banks of the lake is perfectly barren, not producing even a blade of grass; and the earth is full of a saline matter in such plenty, that, after falls of rain or snow, it concretes in white flakes upon the surface, like the natron in Hindostan. Upon the banks of this lake, in the winter season, when the falls of snow begin, the earth is formed into small reservoirs, by raising it into banks about six inches high: when these are filled with snow, the hot water from the lake is thrown upon it, which, together with the water from the melted snow, remains in the reservoir, to be partly absorbed by the earth, and partly evaporated by the sun; after which there remains at the bottom a cake, of sometimes half an inch thick, of crude borax, which is taken up, and reserved for use. It can only be made in the winter season; because the falls of snow are indispensably requisite, and also because the saline appearances upon the earth are strongest at that season. When once it has been made upon any spot, in the manner above described, it cannot be made again upon the same place till the snow shall have fallen upon it, and dissolved three or four times; after which the saline efflorescence re-appears, and it is again fit for the operation.

The borax, in the state above described, is transported from hill to hill upon goats, and passes through many different hands before it reaches the plains, which increases the difficulty of obtaining authentic information regarding the original manufacture. When brought down from the hills, it is refined from the earth and gross impurities, by boiling and crystallization. Mr. Blane could obtain no answers to any questions regarding the quality of the water, and the mineral productions of the soil. All they could say of the former was, that it was very hot, very foul, and as it were greasy; that it boils up in many places, and has a very offensive smell: and the latter remarkable only for the saline appearances above described. That country, however, in general, produces considerable quantities of iron, copper, and sulphur. After being purified, it sells in the market here for about fifteen rupees per maund; and he was assured by many of the natives, that all the borax in India comes only from the place above mentioned.

The other account of borax, in the same volume of the Transactions, is contained in a letter from father Joseph de Rovato, father prefect of the mission in Thibet, who received the information from a native of the country where the borax is prepared, sent expressly for that purpose to him by the brother of the king of Nepal, a kingdom on the borders of Thibet.

This man, partly in the Nepalese, and partly in the Hindoo language, both which are understood by the prefect, gave the following account:—In the province or territory of Marmé, twenty-eight days journey to the north of Nepal, and twenty-five to the west of Lassa, the capital of Thibet, there is a vale about eight miles broad. In a part of this vale there are two villages or castles, the one named Scierugh, and the other Kangle, the inhabitants of which are wholly employed in digging the borax which they sell into Thibet and Nepal, they having no other means of subsistence, the soil being so barren as to produce nothing but a few rushes. Near the two above-mentioned castles there is a pool of moderate

rate

rate size, and some smaller ones, where the ground is hollow, in which the rain water collects. In these pools, after the water has been some time detained in them, the borax is formed naturally : the men wading into the water, feel a kind of pavement under their feet, which is a sure indication that borax is there formed, and there they accordingly dig it.

Where there is little water, the layer of borax is thin ; and where it is deep, it is thicker ; and over the latter there is always an inch or two of soft mud, which is probably a deposit of the water after it has been agitated by rain or wind. Thus is the borax produced merely by nature, without either boiling or distillation. The water in which it is formed is so bad, that the drinking a small quantity of it will occasion a swelling of the abdomen, and in a short time death itself. The earth that yields the borax is of a whitish colour ; and in the same valley, about four miles from the pools, there are mines of salt, which is there dug in great abundance for the use of all the inhabitants of these mountains, who live at a distance from the sea. The natives, who have no other subsistence on account of the sterility of the soil, pay nothing for digging borax ; but strangers must pay a certain retribution, and usually agree at so much a workman. This is paid to a Lama, named Pema Tupkan, who owns the pits in Marmé.

Ten days journey farther north there is another valley, named Tapré, where they dig borax, and another still farther, called Cioga ; but of this latter the prefect did not mark the situation. Borax is, in the Hindoo and Nepalese languages, called Saaga. If it be not purified, it will easily deliquesce ; and in order to preserve it any time till they have an opportunity of selling it, the people often mix it with earth and butter.

It does not appear that borax was known to the ancients, their chryfocolla being a very different substance, composed of the rust of copper, triturated with urine. The word borax is found for the first time in the works of Geber.

Borax is not only found in the East, but likewise in South America. Mr. Anthony Carera *, a physician established at Potosi, informs us, that this salt is abundantly obtained at the mines of Riquintipa, and those in the neighbourhood of Escapa, where it is used by the natives in the fusion of copper ores.

The purification of borax by the Venetians and the Hollanders, was for a long time among those secrets which the want of a sufficient spirit of research prevented from becoming general : chemical writers have been satisfied in asserting that the processes consisted of solution, filtration, crystallization, and calcination. Chaptal, however, informs us, from his own extensive experience, that the destruction of the oily part of borax by calcination is attended with considerable loss. He finds, after trying all the processes in the large way, that the simplest method consists in boiling the borax strongly, and for a long time, with water. This solution being filtered affords by evaporation crystals, which are somewhat foul, but may be purified by repeating the operation.

Purified borax is white, transparent, rather greasy in its fracture, affecting the form of six-sided prisms, terminating in three sided or six-sided pyramids. Its taste is styptic ; it converts syrup of violets to a green, and, when exposed to heat, it swells up, boils, loses its water of crystallization, and becomes converted into a porous, white, opaque mass, commonly called Calcined Borax. A stronger heat brings it into a state of quiet fusion : but the glassy substance thus afforded, which

* Quoted by Chaptal in his Elements of Chemistry.

is transparent, and of a greenish yellow colour, is soluble in water, and effloresces in the air.

This salt requires about eighteen times its weight of water to dissolve it at the temperature of sixty degrees of Fahrenheit; but water at the boiling heat dissolves three times this quantity. Borax is used as an excellent flux in docimastic operations. It enters into the composition of reducing fluxes, and is of the greatest use in analyses by the blow-pipe. It may be applied with advantage in glass manufactories; for when the fusion turns out bad, a small quantity of borax re-establishes it. It is more especially used in foldering: it assists the fusion of the folder, causes it to flow, and keeps the surface of the metals in a soft or clean state, which facilitates the operation. It is scarcely of any use in medicine. Sedative salt alone is used by some physicians; and its name sufficiently indicates its supposed effects.

Borax has the inconvenience of swelling up, and requires the greatest attention on the part of the artist who uses it in delicate works, more especially when designs are to be formed with gold of different colours. It has been long a desideratum to substitute some composition in the room of borax, which might possess its advantages without its defects.

M. Georgi has published the following process:—"Natron, mixed with marine salt and Glauber's salt, is to be dissolved in lime water; and the crystals which separate by the cooling of the fluid may be set apart. The lixivium of natron is then to be evaporated; and this salt afterwards dissolved in milk. The evaporation affords scarcely one-eighth of the natron employed; and the residue may be applied to the same uses as borax."

Messrs. Struve and Exchaquet have proved that the combination of phosphoric acid and vegetable alkali, fused with a due proportion of phosphorated lime, forms an excellent glass for foldering metals.

BOVEY COAL. Xylanthrax. This is of a brown or brownish black colour, and lamellar texture; the laminae are frequently flexible when first dug, though generally they harden when exposed to the air. It consists of wood penetrated with petrol or bitumen, and frequently contains pyrites, alum and vitriol; its ashes afford a small quantity of fixed alkali, according to the German chemists*; but according to Mr. Mills†, they contain none. By distillation it yields an ill-smelling liquor, mixed with volatile alkali and oil, part of which is soluble in spirits of wine, and part insoluble, being of a mineral nature.

It is found in England, France, Italy, Switzerland, Germany, Iceland, &c.

BRANDY. This well-known fluid is the ardent spirit distilled from wine. The greatest quantities are made in Languedoc, where this manufacture, upon the whole so pernicious to society, first commenced. It is obtained by distillation in the usual method, by a still, which contains five or six quintals of wine, and has a capital and worm tub applied. Its peculiar flavour depends, no doubt, on the nature of the volatile principles, or essential oil, which come over along with it, and likewise, in some measure, upon the management of the fire, the wood of the cask in which it is kept, &c. It is said, that our rectifiers imitate the flavour of brandy, by adding a small proportion of nitrous acid to the spirit of malt or melasses. See SPIRIT OF WINE.

BRASS. An elegant yellow-coloured compound metal, consisting of cop-

* 2 Gerb. Beytr. 271.

† Phil. Transf. 1760.

per combined with about one-third of its weight of zinc. The best brafs is made by cementation of calamine, or the ore of zinc, with granulated copper. *See COPPER.*

BRASSICA RUBRA. Mr. Watt finds that the red cabbage affords a very excellent test, both for acids and alkalis; in which it is superior to litmus, being naturally blue, turning green with alkalis, and red with acids; besides which it possesses the advantage of not being affected by the fuming nitrous acid, any further than as it acts as a real acid. The management of the leaves to procure this test, is as follows, in the words of the author*:

“To extract the colouring matter, take those leaves of the cabbage which are freshest, and have most colour; cut out the larger stems, and mince the thin parts of the leaves very small; then digest them in water of about the heat of one hundred and twenty degrees for a few hours, and they will yield a blue liquor, which, if used immediately as a test, will be found to possess great sensibility. But as this liquor is very apt to turn acid and putrid, and to lose its sensibility when it is wanted to be preserved for future use, the following processes succeed the best:

1. After having minced the leaves, spread them on paper, and dry them in a gentle heat; when perfectly dry, put them up in glass bottles well corked; and when you want to use them, acidulate some water with vitriolic acid, and digest or infuse the dry leaves in it until they give out their colour; then strain the liquor through a cloth, and add to it a quantity of fine whiting or chalk, stirring it frequently until it becomes of a true blue colour, neither inclining to green nor purple: as soon as you perceive that it has acquired this colour, filter it immediately, otherwise it will become greenish by longer standing on the whiting.

This liquor will deposit a small quantity of gypsum, and by the addition of a little spirit of wine will keep good for some days, after which it will become a little putrid and reddish. If too much spirit is added, it destroys the colour. If the liquor is wanted to be kept longer, it may be neutralized by means of a fixed alkali instead of chalk.

2. But as none of these means will preserve the liquor long, without requiring to be neutralized afresh, just before it is used; and as the putrid and acid fermentation which it undergoes, and perhaps the alkalis or spirit of wine mixed with it, seem to lessen its sensibility; in order to preserve its virtues while it is kept in a liquid state, some fresh leaves of the cabbage, minced as has been directed, may be infused in a mixture of vitriolic acid and water, of about the degree of the acidity of vinegar: and it may be neutralized, as it is wanted, either by means of chalk, or of the fixed or volatile alkali. But it is necessary to observe, that if the liquor has an excess of alkali, it will soon lose its colour, and become yellow, from which state it cannot be restored; therefore care should be taken to bring it very exactly to a blue, and not to let it verge towards a green †.

By the same process I have made a red infusion of violets, which, on being neutralized, forms at present a very sensible test: but how long it will preserve its properties I have not yet determined. Probably the coloured infusions of other

* Phil. Trans. vol lxxiv.

† Since writing the above, I have found that the infusions of red cabbages and of various flowers in water, acidulated by means of vitriolic acid, are apt to turn mouldy in the summer season, and also, that the moulding is prevented by the addition of spirits of wine. The quantity of spirit which is necessary for this purpose, I have not been able to ascertain; but I add it by a little at a time, until the progress of the moulding is prevented. Watt.

flowers may be preserved in the same manner, by the antiseptic power of the vitriolic acid, so as to lose little of their original sensibility. Paper fresh stained with these tests in their neutral state, has sufficient sensibility for many experiments: but the alum and glue which enter into the preparation of writing paper, seem in some degree to fix the colour; and paper which is not sized becomes somewhat transparent when wetted, which renders small changes of colour imperceptible; so that, where accuracy is required, the test should be used in a liquid state *."

BRAZIL WOOD. This wood is of the growth of the Brazils in South America, and also of the Isle of France, Japan, and elsewhere. It is chiefly used in the processes of dying. This wood is considerably hard, is capable of a good polish, and is so heavy, that it sinks in water. Its colour is pale when newly cut, but it becomes deeper by exposure to the air. The various specimens differ in the intensity of their colour; but the heaviest is reckoned the most valuable. It has a sweetish taste when chewed, and is distinguished from red sanders, or sandal, by its property of giving out its colour with water, which this last does not.

If the Brazil wood be boiled in water for a sufficient time, it communicates a fine red colour to that fluid. The residue is very dark coloured, and gives out a considerable portion of colouring matter to a solution of alkali. Ardent spirit extracts the colour from Brazil wood, as does likewise the volatile alkali; and both these are deeper than the aqueous solution. The spirituous tincture, according to Dufay, stains warm marble of a purplish red, which on increasing the heat becomes violet; and if the stained marble be covered with wax, and considerably heated, it changes through all the shades of brown, and at last becomes fixed of a chocolate colour.

The recent decoction of Brazil wood, according to Berthollet †, affords, by the addition of vitriolic acid, a precipitate, small in quantity, and of a red colour inclining to yellow; the liquor remaining transparent, and of a yellow colour. The nitrous acid first converts the tincture to a yellow; but if the quantity of acid be increased, the liquor assumes a deep orange yellow, and becomes transparent, after depositing a precipitate of the same colour nearly as the foregoing, but more abundant. The muriatic acid has the same effect as the vitriolic. The saccharine or oxalic acid affords an orange red, or almost ruddy precipitate, nearly as abundant as that thrown down by the nitrous acid, and the liquor remains transparent and yellow. Distilled vinegar affords a very sparing precipitate of the same colour; the fluid continuing transparent, but rather of a deeper orange. Tartar affords still less precipitate; and the remaining liquor is turbid and more reddish than the last. Fixed alkali converts the colour of the decoction to a crimson or deep violet, inclining to brown, and affords a precipitate of the same colour, though very small in quantity. Volatile alkali affords a brighter violet or purple, and a little precipitate of a fine purple. Alum throws down a red precipitate inclining to crimson, which is abundant and subsides very slowly; while the supernatant fluid preserves its fine red colour, like that of the recent decoction: this liquor affords another abundant precipitate, if the acid of the alum be saturated with an alkali. In this manner is prepared a kind of carmine, inferior in beauty

* I have found that the petals of the scarlet rose, and those of the pink-coloured lychnis, treated in this manner, afford very sensible tests. Watt.

† In his *Elémens de l'Art de la Teinture*, from which the present article is chiefly extracted. Dr. Hamilton promises a translation of this excellent work.

to the common carmine, and likewise a liquid lake for miniature painters. Alum and tartar together afford a brownish red precipitate in small quantity, while the fluid remains of a bright orange red. Vitriol of iron gives the tincture a black colour, inclining to violet, at the same time that an abundant precipitate of the same colour falls down. Vitriol of copper likewise affords a plentiful brown precipitate, and converts the fluid to a transparent brownish red. Vitriol of zinc throws down a sparing brown precipitate, leaving the fluid of an amber colour. Solution of sugar of lead affords a precipitate of deep red, of considerable beauty, and the liquor becomes of an orange red. The solution of tin in aqua regia occasions an abundant precipitate of a fine rose colour, and the fluid remains clear and quite colourless. Lastly, corrosive sublimate occasions a slight brown precipitate; the liquor remaining transparent, and of a fine yellow colour.

The Journal de Physique for February 1785 contains some curious experiments respecting the action of acids upon the colour of Brazil wood. If the aqueous tincture of this wood be first rendered yellow by means of tartar and the acetic acid, and the solution of tin in aqua regia be then poured in, a very abundant rose-coloured precipitate is obtained: if to the solution rendered yellow by an acid there be added a greater quantity of the same or a stronger acid, the red colour is restored; the vitriolic acid is best adapted to this effect. Several salts likewise cause the red colour of Brazil wood to appear again after it has been destroyed by the action of acids.

It has been observed that the recent decoction of Brazil wood is less proper for dying than that which is older, or even fermented; it assumes a yellowish red colour by age. Hellot recommends the hardest waters for making this decoction; but it must be observed that such waters deepen the colour, by virtue of the earthy salts they contain. After boiling the chips of this wood for three hours, this first decoction is put into a cask. More water is then added to the wood, which is boiled for a second three hours, and the decoction added to the foregoing. In this, as in all decoctions of colouring wood, the wood is kept in a bag of porous cloth.

Wool plunged in the decoction of Brazil wood acquires a weak colour, which soon goes off. It therefore requires a preparation to render the dye permanent.

The wool must be boiled in a solution of alum, to which one fourth or even a less quantity of tartar has been added. A larger proportion of tartar would render the colour deeper. The impregnated wool is kept at least eight days in a cool place; after which it is dyed in the decoction of Brazil wood by a gentle boiling. As the colouring matter first deposited affords an inferior dye, it is proper to dip a coarser stuff first. In this way a lively red dye is obtained, which resists the air very well.

If the red colour of Brazil wood be destroyed by an acid, it communicates a very durable fawn colour to woollen stuffs.

M. Poerner prepares the stuff by boiling it in a solution of tin, alum, and a little tartar; and he makes his bath with the Brazil wood, and a considerable proportion of alum. In the residue of this bath he dips another piece which has received the same preparation. The first piece receives a fine brick colour, and the second a dye approaching to scarlet*. The shades may be greatly varied by altering the proportion of the ingredients.

By these means the dyes obtained from Brazil wood may be rendered considerably solid; but by no means comparable in this respect to those afforded by

* Instruction sur l'Art de Teinture.

cochineal or madder. The dye afforded by this last substance is sometimes rendered brighter, by passing the dyed stuff through a decoction of Brazil; but the effect soon goes off.

M. Guhliche describes a process, which, as he affirms, is capable of affording more beautiful and more durable colours than those before used: he directs, that vinegar, or the *aceto-citric acid, or aqua regia, be poured upon the Brazil wood, reduced into powder, or thin shavings or chips, until it be covered to a certain depth. This mixture must be well agitated, then left at rest for twenty-four hours, and lastly decanted, filtered, and preserved for use. A vegetable acid, or simple water, is poured on the residue, and left to repose for a day or two, after which it is filtered; and in this manner the process is continued until no more colour is given out; the wood is then black: the several liquors are to be mixed together.

The stuff is prepared by a weak galling with sumach, or the white nut gall: after this it is slightly alumed, simply rinsed and immersed wet with the following bath:

The acid solution of Brazil wood is taken and diluted with a certain quantity of water, depending on the quantity of goods, and the intensity of the colour intended to be produced. It is then heated to such a degree that the hand may be held in it; solution of tin is then poured in until it has acquired a fine colour; the bath being then agitated, the stuff is to be plunged in and kept immersed for half an hour, after which time it is to be taken out and washed. The remaining bath will serve for weaker shades, and the stuff must not be galled for these light tinges.

Brazil wood is used for dying silk of a crimson colour. This is called the false dye, to distinguish it from the crimson obtained by cochineal, which is much more durable.

The silk must be boiled with twenty pounds of soap for every hundred of silk, and afterwards alumed. The aluming need not be so strong as for the fine crimson. It is then washed in a running stream, and immersed into a bath, more or less charged with the decoction of Brazil wood, according to the intended shade of colour. When water containing no earthy salt has been made use of, the colour is too red to imitate crimson. This quality however is given to the water by passing the silk through a slight alkaline solution, or by adding a little alkali to the bath. It might likewise be washed in hard water till it had obtained the required shade.

To make a deeper crimson of the false or red brown kind, the decoction of logwood is added to the bath of Brazil wood, after the silk is impregnated. A

* This acid, so called by M. Berthollet, but distinguished by M. Guhliche by the name of the vegetable acid spirit, is much used by this last chemist in his dying processes, and is prepared as follows:

He takes lemons, not rejecting even those whose skin is quite rotten; pares them, slices them into an earthen or metallic (but not a wooden) vessel; sprinkles them with good vinegar, of the strength which he judges to be equal to that of lemon-juice; expresses the juice from the lemons, exposed to the action of a press in a flannel bag; and lastly filters it through paper. In this state the liquor may be employed with success; but it has the inconvenience of becoming mouldy, and is aqueous. To remedy these defects, he recommends it to be purified and concentrated as follows: The liquor is left exposed to the sun until it has become clear and deposited a sediment. It is then filtered and distilled on a sand bath. As soon as the drops which come over are perceived to be acid, the receiver is changed, and the distillation is continued until oily stræ are perceived in the neck of the retort. The acid which is thus obtained must be preserved for use.

small quantity of alkali is likewise added, according to the shade intended to be produced.

To imitate the wild poppy, or fiery red, the silk must first receive a ground of *rocou* (better known in England by the name of *ANNOTTO*, which see), even deeper than when the dye with *carthaucus* is intended; after which it is washed, alumed, and dyed with the decoction of Brazil wood, to which a little soap water is usually added.

The solution of tin cannot, as M. Berthollet observes, be employed with the decoction of Brazil wood, for dyeing silk in the same manner as with cochineal, because the colouring particles are too quickly separated to be able to fix themselves on the silk, which has not so strong an attraction for them as wool has. But, as Bergman remarks, in his notes upon Scheffer's Essay on the Art of Dyeing, it is possible to make great improvement in the colours afforded by the dyeing woods, by macerating the silk in a cold solution of tin. A strong decoction of Brazil wood gives to yellow silk a scarlet colour, inferior indeed to that of cochineal, but much more lively and solid than is had by mere maceration in alum, and capable of resisting the proof of vinegar, like the fine crimson and poppy colours. Instead of using the raw silk, it is requisite to give a yellow ground to boiled silk, or to mix a yellow substance with the decoction of Brazil wood. Several manufacturers have lately busied themselves with this process, and have produced a variety of effects, by applying it to different colouring matters, which afford colours of very little solidity, whether they be employed alone, or in forming different mixtures.

M. Gühliche nevertheless describes a process, in which he makes an immediate use of the solution of tin, to give a fire colour to silk. He directs that it should be galled by a solution of nut galls in white wine. He affirms that this solution preserves much more of that brilliancy, so much in request in the colour of silk, than the solution made in water. He adds such a quantity of this solution to water as may give the whole a yellow colour; with this he carefully impregnates the silk, leaving it in the cold for twelve hours, after which he expresses the liquor very well, but without the action of washing. The silk being then dried is steeped in a solution of alum, in the proportion of four ounces of alum for every pound of the silk, where it remains for twelve hours. He then presses out the acid, and immerses the silk, wet as it is, into a bath prepared in the way already described, after having added an ounce of the solution of tin. The remaining force of the bath may be exhausted for lighter shades. If the fire colour be required more inclining to orange, he does not gall the silk, but alums it in a cold solution of two ounces of alum, of the strength of two ounces of the salt for every pound of the silk; after which he dyes it of an orange colour with *annotto*, without boiling, and plunges it still wet into the before-mentioned bath of Brazil wood. The author confesses, that these colours, more especially the last, do not possess much solidity. For rose colours he omits the galling, and uses no more than two ounces of alum. For light shades he recommends to decant the solution of alum from the deposition it may have made; and he prefers dyeing without heat, by employing a bath more highly charged with colour, out of which the silk may be taken when it has received the intended shade, and which may be afterwards exhausted in producing other shades. He affirms that, by the assistance of these precautions, beautiful shades may be obtained of sufficient solidity.

M. Poerner has made a great number of essays on the methods which may be used to dye cotton by means of Brazil wood, with different mordants, such as alum, the solution of tin, sal ammoniac, alkali, &c. either in the bath or in the pre-

paration of the stuff; but he could not produce colours capable of resisting the action of soap, though several among them withstood the action of the air, and washing in water. He advises that the cottons dyed with these colours should be dried in the shade.

The following process, used in some manufactories for dyeing cotton of a crimson colour, was communicated to M. Berthollet by Mr. Brown.

A solution of tin is made in these proportions of the ingredients: nitrous acid two pounds, muriatic acid one pound, tin eight ounces, water one pound: the fluids are to be mixed, and the tin dissolved in the mixture by adding a little at a time.

For a piece of cotton velvet, weighing fifteen or sixteen pounds, the operation is begun by preparing a bath composed of four parts boiling water, and two parts of a strong decoction of nut-galls. The bath is then stirred with the rake, the piece plunged in it worked for half an hour, left immersed for two hours, and afterwards taken out and drained. Another bath is also prepared with three parts of boiling water, and one of the decoction of Brazil wood likewise boiling; this is raked, and the piece worked in it for half an hour. The liquor is then thrown out, and the vat filled with a decoction of Brazil wood, unmixed and boiling. In this the piece is worked for half an hour, and then lifted out on a cross. A bath of very clear river water is then prepared, in which a pint of solution of tin is poured; and when the bath has been well raked, and the piece worked for half an hour, it is taken out on the cross, and carried to the bath of the decoction of Brazil wood, out of which one sixth part of the whole has been taken, and replaced with an equal quantity of the boiling decoction. In this bath the piece is worked for half an hour, then raised on the cross, and returned to the bath, which contains the solution of tin. These alternate operations are repeated six or eight times; taking care every time to take out one sixth of the bath of the Brazil or Fernambouc wood, and to replace it with an equal quantity of the boiling decoction of the same wood, to rake or stir the bath of the composition every time, and to finish the dye by the piece remaining in the latter bath. The piece is last of all to be washed in plenty of water, or a stream, and it must be dried in a place inaccessible to the light.

The colouring particles of Brazil wood are easily affected and rendered yellow by acids, after which change they become solid colours. But what distinguishes them from madder and kermes, and indicates a resemblance to cochineal, is that they appear again in their original colour, when precipitated with alum, or the calx of tin. These two combinations appear the most proper to render the colour durable. It is necessary, therefore, to enquire after and ascertain the circumstances most proper to favour their combinations, according to the nature of the stuff.

The astringent principle likewise appears to contribute to the solidity of the colouring parts of Brazil wood: but this galling renders the colour deeper, and cannot be used for light shades.

The colouring parts of Brazil wood are very sensible to the action of alkalis, which give them a purple tinge; and there are many processes in which fixed or volatile alkalis are used to form violets and purples: but the colours, though obtained with ease in various shades by this method, are perishable, and possess only a transient brightness. Alkalis do not appear to injure the colours afforded by madder, but they hasten the destruction of most other colours.

It is usual in England to rasp or pulverize the dyeing woods in mills appropriated to that purpose. They are commonly kept moistened with urine; and when urine has not been used, a small quantity of alkali is added at the time of boiling.

boiling. This method of proceeding, as M. Berthollet observes, is very advantageous; but the use of putrefied urine, or alkali, tends to deepen the colour, to render it less permanent, and may, on various occasions, be contrary to the nature of the processes intended to afford certain effects.

BREAD. I am not acquainted with any set of experiments regularly instituted and carried into effect, for ascertaining what happens in the preparation of bread. Farinaceous vegetables are converted into meal by trituration, or grinding in a mill; and when the husk or bran has been separated by sifting or bolting, the powder is called flour. This is composed of a small quantity of mucilaginous saccharine matter, soluble in cold water, much starch, which is scarcely soluble in cold water, but combines with that fluid by heat, and an adhesive grey substance insoluble in water, ardent spirit, oil, or ether, and resembling an animal substance in many of its properties. *See FARINA, STARCH, GLUTEN VEGETABLE, MUCILAGE.*

When flour is kneaded together with water, it forms a tough paste, containing these principles very little altered, and not easily digested by the stomach. The action of heat produces a considerable change in the gluten, and probably in the starch, rendering the compound more easy to masticate, as well as to digest. Hence the first approaches towards the making of bread consisted in parching the corn, either for immediate use as food, or previous to its trituration into meal; or else in baking the flour into unleavened bread, or boiling it into masses more or less consistent; of all which we have sufficient indications in the histories of the earlier nations, as well as in the various practices of the moderns. It appears likewise from the Scriptures, that the practice of making leavened bread is of very considerable antiquity; but the addition of yeast, or the vinous ferment, now so generally used, seems to be of modern date.

Unleavened bread in the form of small cakes, or biscuit, is made for the use of shipping in large quantities; but most of the bread used on shore is made to undergo, previous to baking, a kind of ferment, which appears to be of the same nature as the fermentation of saccharine substances; but is checked and modified by so many circumstances as to render it not a little difficult to speak with certainty and precision respecting it.

When dough or paste is left to undergo a spontaneous decomposition in an open vessel, the various parts of the mass are differently affected, according to the humidity, the thickness, or thinness of the part, the vicinity or remoteness of fire, and other circumstances less easily investigated. The saccharine part is disposed to become converted into ardent spirit, the mucilage has a tendency to become sour and mouldy, while the gluten in all probability verges toward the putrid state. An entire change in the chemical attractions of the several component parts must then take place in a progressive manner, not altogether the same in the internal and more humid parts as in the external parts, which not only become dry by simple evaporation, but are acted upon by the surrounding air. The outside may therefore become mouldy or putrid, while the inner part may be only advanced to an acid state. Occasional admixture of the mass would of course not only produce some change in the rapidity of this alteration, but likewise render it more uniform throughout the whole. The effect of this commencing fermentation is found to be, that the mass is rendered more digestible and light; by which last expression it is understood, that it is rendered much more porous by the disengagement of elastic fluid, that separates its parts from each other, and greatly increases its bulk. The operation of baking puts a stop to this process,

cess, by evaporating great part of the moisture which is requisite to favour the chemical attraction, and probably also by still farther changing the nature of the component parts. It is then bread.

Bread made according to the preceding method will not possess the uniformity which is requisite; because some parts may be mouldy, while others are not yet sufficiently changed from the state of dough. The same means are used in this case as have been found effectual in promoting the uniform fermentation of large masses. This consists in the use of a leaven or ferment, which is a small portion of some matter of the same kind, but in a more advanced stage of the fermentation. After the leaven has been well incorporated by kneading into fresh dough, it not only brings on the fermentation with greater speed, but causes it to take place in the whole of the mass at the same time: and as soon as the dough has by this means acquired a due increase of bulk from the fixed air, which endeavours to escape, it is judged to be sufficiently fermented, and ready for the oven.

The fermentation, by means of leaven or sour dough, is thought to be of the acetous kind, because it is generally so managed that the bread has a sour flavour and taste. But it has not been ascertained that this acidity proceeds from true vinegar. Bread raised by leaven is usually made of a mixture of wheat and rye, not very accurately cleared of the bran. It is distinguished by the name of brown bread; and the mixture of these two kinds of grain is called bread-corn in many parts of the kingdom, where it is raised on one and the same piece of ground, and passes through all the processes of reaping, threshing, grinding, &c. in this mixed state.

Yeast or barm is used as the ferment for the finer kinds of bread. This is the mucilaginous froth which rises to the surface of beer in its first stage of fermentation. When it is mixed with dough, it produces a much more speedy and effectual fermentation than that obtained by leaven, and the bread is accordingly much lighter, and scarcely ever sour. The fermentation by yeast seems to be almost certainly of the vinous or spirituous kind.

Bread is much more uniformly miscible with water than dough, and on this circumstance its good qualities most probably do in a great measure depend.

A very great number of processes are used by cooks, confectioners, and others, to make cakes, puddings, and other kinds of bread in which different qualities are required. Some cakes are rendered brittle, or as it is called *short*, by an admixture of sugar or of starch. Another kind of brittleness is given by the addition of butter or fat. White of egg, gum-water, isinglass, and other adhesive substances are used, when it is intended that the effect of fermentation shall expand the dough into an exceedingly porous mass. The reflecting chemist will receive considerable information on this subject from an attentive inspection of the receipts to be met with in treatises of cooking and confectionary.

BRECCIA. An Italian term frequently used by our mineralogical writers, to denote such compound stones as are composed of agglutinated fragments of considerable size. When the agglutinated parts are rounded, the stone is called pudding-stone. Breccias are denominated according to the nature of their component parts. Thus we have calcareous breccias, or marbles, and siliceous breccias, which are still more minutely classed, according to their varieties. See the Mineralogies of Cronstedt, Kirwan, and others.

BRICK. Among the numerous branches of the general art of fashioning argillaceous earths into useful forms, and afterwards hardening it by fire, the art of making

making bricks and tiles is by no means one of the least useful. By this art we possess the advantage of obtaining the materials for constructing edifices at cheap rates, in almost every situation, without the expence of carrying stone from remote quarries; and this is so far from being the only advantage, that it is extremely probable that these artificial compositions, if properly made, would prove superior in durability to every natural stone. The streets in Holland are every where paved with a hard kind of brick, known by us under the name of clinkers, and used in this country for paving stables and court-yards; and the houses in Amsterdam appear to be not at all decayed, but were perfectly fresh, as if new, though most of those in the vicinity of the Exchange have stood at least two centuries. The spirit of improvement may perhaps effect at some future period, in this country, what the stimulus of necessity has done on that naturally poor spot.

The art of brickmaking has for the most part been confined to the manufactories, no one having attended to it in a direct chemical way, except the celebrated Bergman. I shall therefore in the present article give an account of the leading facts and observations in his treatise*.

The pottery made use of in the construction of edifices may be considered as of two forms; tiles for the roof, or bricks for the walls; to which may be added another kind of bricks for pavements. Softness and porosity are the greatest faults of tiles. The water retained in the pores of tiles becomes frozen in winter; and as ice occupies a larger space than water, the expansion of the water, at the instant of its congelation, does not fail to split and destroy such porous and brittle substances as tiles which are ill made. This has been remedied by covering them with a glaze, which adds considerably to the expence. Bergman is of opinion that a stronger heat used in the baking would render them so close as to absorb very little moisture.

This illustrious chemist did not find that pure clay, or argillaceous earth, was fusible either alone or when mixed in any proportion with lime, though the addition of the smallest quantity of siliceous earth brought the mass into fusion. Neither was clay fusible with pure quartz alone. Fluor mineral renders it fusible as does likewise feld spar.

Common clay is scarcely ever found in a state approaching to purity on the surface of the earth. It usually contains a large proportion of siliceous earth. Bergman examined several clays in the neighbourhood of Upsal, and made bricks, which he baked with various degrees of heat, suffered them to cool, immersed them in water for a considerable time, and then exposed them to the open air for three years. They were formed of clay and sand. The hardest were those, into the composition of which a fourth part of sand had entered. Those which had been exposed for the shortest time to the fire were almost totally destroyed, and crumbled down by the action of the air: such as had been more thoroughly burned, suffered less damage; and in those which had been formed of clay alone, and were half vitrified by the heat, no change whatever was produced.

On the whole, he observes, that the proportion of sand to be used to any clay, in making bricks, must be greater, the more such clay is found to contract in burning; but that the best clays are those which need no sand. Bricks should be well burned; but no vitrification is necessary when they can be rendered hard enough by the mere action of the heat. Where a vitreous crust might be deemed necessary, he recommends the projection of a due quantity of salt into

* Physical and Chemical Essays, vol. iii. p. 378.

the furnace, which would produce the effect in the same manner as is seen in the fabrication of the English pottery, called stone ware.

It is of considerable importance to examine clay before it is made into tiles. This is done in a rough way by the manufacturers; but Bergman advises the following as the most expeditious process: Nitrous acid poured upon unburned clay detects the presence of lime, by producing an effervescence. Calcareous clays, or marles, are often the fittest materials for making bricks. In the next place, a lump of clay, of a given weight, is to be diffused in water by agitation. The sand will subside, and the clay remain suspended. Other washings of the residue will carry off some clay, and, by due management in this way, the sand, or quartzose matter, may be had separate. Nitrous acid by digestion will take up the lime from a part of the clay, previously weighed, and this may be precipitated by volatile alkali. The clay, the sand, and the lime may thus be well enough ascertained by weight, so as to indicate the quantity of sand or other material requisite to be added in order to form that compound, which, from other experiments, may have been found best adapted to produce good tiles and bricks. An examination with the microscope will shew whether the sand contain feld, spar, or other stones of known figure.

The brickmakers in the vicinity of London collect the refuse cinders and ashes of the coal fires of that metropolis, and employ women to sift them. The cinders are used as fuel in the burning, and the smaller powder, or black ashes, enter into the composition of the bricks instead of sand.

BRIMSTONE. See **SULPHUR**.

BROCATELLO. A calcareous stone or marble, composed of fragments of four colours, white, grey, yellow, and red.

BRONZE. A mixed metal consisting chiefly of copper, with a small proportion of tin, and sometimes other metals. It is used for casting statues, cannon, bells, and other articles, in all which the proportions of the ingredients vary. The addition of tin to copper renders it brittle and hard, singularly augments its density, and makes it more fusible. The compound possesses likewise the advantage of being less subject to corrosion, or rust, by exposure to the air. Cannon and statues have less tin in their composition than bells; and in speculum metal the proportion is greatest of all. See **SPECULUM**.

The operation by which large works of bronze are cast, as described by Macquer, is sufficiently simple. For this purpose a brick furnace is used, nearly in the shape of a baker's oven. The floor of this furnace is concave, and consists of a composition of sand and clay. In this hollow floor the metals are put. The furnace has four openings.

The first is a lateral mouth, at which the flame of the fuel enters, which is placed in a second furnace on one side the first. The second opening is a chimney placed on the side opposite the mouth, by means of which the flame is drawn over the metal. The third opening is a hole, which can be shut or opened at pleasure, to inspect the state of the inside of the furnace and its contents. When the metal is in the state required, a fourth opening is then inclosed, communicating with the hollow floor, through which the melted metal flows by channels into the moulds prepared to receive it.

The recovery of copper from old bell metal is an object which is sometimes desirable. Chemistry affords various methods of doing this, an interesting detail of which may be seen in the ninth volume of the *Annales de Chimie*.

BUTTER.

BUTTER. The oily inflammable part of milk, which is prepared in many countries as an article of food. This substance appears to be diffused through milk, either mechanically, or, which is more probable, by an imperfect chemical union; that is, by combination with the caseous, saccharine, and acid parts, which form the medium of its suspension in the aqueous fluid. When milk is suffered to remain at rest for several hours, a thick fluid rises to the top, well known by the name of cream, and consisting of the butter, together with a considerable mass of caseous and ferous particles. It has not been ascertained whether this ascent of the cream be attended with any chemical change or ferment of the whole fluid; but it seems very probable that this is the case.

Butter as it exists in cream does not form continued masses, but has its parts separated by the interposition of the other principles. Some butter will however be separated without any operation, farther than the mere continuance of standing undisturbed. But the common method of separating it consists in agitating the cream, for a certain time, in a vessel called a churn, the form of which is various, but its essential purpose the same. By this treatment it is collected in an uniform soft mass, possessing scarcely any smell; of a mild agreeable taste, easily fusible, and suffering no perceptible disengagement of any of its principles by any degree of heat not exceeding that of boiling water.

We do not possess any direct experiments to shew what it is that occasions the difference between the obvious qualities of butter and those of other oils, distinguished by the name of fat or fixed oils, from their not rising by a low heat. It resembles them in its habitudes as nearly as they resemble each other respectively. By distillation on the water bath it gives out a portion of watery fluid, that either remained interposed between its parts from the first, or was taken up during the washing it undergoes in the making. A stronger heat, carefully managed, expels first a strong acid of a penetrating smell, which is followed by a concrete coloured oil possessing the same odour. Very little coal remains. The acid appears to be of the same nature as that distinguished by the name of the acid of fat: and it may also be obtained from butter by means of lime or an alkali. *See ACID OF FAT.*

Butter becomes rancid sooner than most other fat oils, probably on account of the water, which may favour the development of its acid. Washing with water or ardent spirit restores it in some measure to its former state, by carrying off the disengaged part of the acid. Fixed alkalis dissolve butter, and form soap.

BUTTER OF ANTIMONY. The combination of the regulus of antimony with the dephlogisticated or aerated marine acid. It is usually made by distilling a mixture of corrosive sublimate and the regulus. *See ANTIMONY.*

BUTTER OF ARSENIC. A combination of the regulus of arsenic with dephlogisticated or aerated marine acid; obtained by a process similar to that used in making the butter of antimony.

BUTTER OF CACAO. An oily concrete white matter, of a firmer consistence than suet, obtained from the cacao nut, of which chocolate is made. The method of separating it consists in bruising the cacao and boiling it in water. The greatest part of the superabundant and uncombined oil contained in the nut is by this means liquefied, and rises to the surface; where it swims, and is left to congeal, that it may be the more easily taken off. It is generally mixed with small pieces of the nut, from which it may be purified by keeping it in fusion without water in a pretty deep vessel, until the several matters have arranged

themselves according to their specific gravities. By this treatment it becomes very pure and white.

Butter of cacao is without smell, and has a very mild taste, when fresh; and in all its general properties and habitudes it resembles fat oils; among which it must therefore be classed. It is used as an ingredient in pomatums.

BUTTER OF WAX. Wax, though differing very considerably from fat oils, resembles them in affording an acid by distillation, while the remaining oleaginous part becomes more limpid, in proportion as the number of distillations is repeated. The first distillation leaves it of a butyraceous consistence, and this is called butter of wax. It has a strong smell, and is said by Macquer not to recover its consistence by long exposure to the air; in which particular he observes that it differs from resinous substances.

BUTTER OF TIN. When granulated tin, or an amalgam of tin and mercury, is distilled with corrosive sublimate, the tin rises in combination with the dephlogisticated or aerated marine acid, partly in the form of a liquor and partly in butyraceous flowers. The liquor is called the fuming liquor of Libavius, and is not essentially different from the flowers. Many chemists distinguish the whole product by the name of the fuming liquor of Libavius. See **TIN**.

BUTTON. The round mass of metal obtained in small reductions or other chemical experiments, and found at the bottom of the crucible or vessel wherein the operation is performed, is called the button by chemists.

BYSSUS. The asbestos, composed of parallel fibres, is distinguished by some under this name.

C.

CABOCHON. The French use this word to denote the figure of precious stones when polished with a convex surface.

CACHOLONG. A very hard compact white agate. It is semi-transparent, and in this respect differs from the moonstone, which has a milky white, with a few various shades of light proceeding from an internal blueish ground. The cacholong is vitrifiable and capable of a good polish. It is found in the river Cache in the Calmucks' country, whence in their language it takes its name.

CADMIA. A word scarcely met with in the writings of the later chemists. It has been given to various substances. The cadmia of the furnaces is a matter that sublimes when ores containing zinc, like those of Rammelsburg, are smelted. This consists of the flowers of zinc, which rise by the violent heat of combustion, and adhere to the inside of the walls of the furnace; which being hot do not condense them immediately into the solid state, but cause them to pass through a state of fluidity intermediate between the elastic and the solid state. On this account they have a much less interrupted solidity than the flowers of zinc usually possess. The quantity collected at Rammelsburg is so considerable as

to form a very thick crust, requiring to be frequently removed. The name of cadmia has also been given to other sublimes that rise in the smelting of ores.

Calamine, or lapis calaminaris, which is an ore of zinc, has also been called native cadmia. This, as well as the cadmia of the furnaces, is used in the converting copper into brass. *See COPPER.*

The ore of cobalt is sometimes, but very improperly, called fossil cadmia.

CÆRULEUM MONTANUM. An ore of copper classed by Cronstedt among the calcareous earths, as a combination of that earth with the metal. Kirwan, however, asserts positively that 100 parts contain about 69 of copper, 29 of aerial acid or fixed air, and 2 of water. It is most frequently found of a loose pulverulent form, though sometimes indurated and even crystallized, but it is then mixed with quartz. It may be analysed by solution in acids, and precipitation by immersing a piece of iron in the solution, which will throw down the copper in the metallic state.

CALAMINE. An ore of zinc of a white, grey, yellow, brown, or red colour, of various hardness, though scarcely ever hard enough to strike fire with the steel. Its texture is either equable or cellular, and its form irregular, or crystallized, or in stalactites. It does not lose weight by calcination, unless mixed with charcoal; and then the zinc rises in flowers. Acids dissolve it, and with the vitriolic it affords vitriol of iron as well as of zinc. The specific gravity of the best sort, that is the grey, is 5,000, and 100 parts of this afforded Bergman 84 of calx of zinc, 3 iron, 1 clay, and 12 siliceous earth; but in other specimens the proportions are very different. Most of the English calamines contain lead.

CALCAREOUS EARTH. *See EARTHS.*

CALCES, METALLIC. Metals which have undergone the process of calcination or combustion, or any other equivalent operation.

CALCINATION. The fixed residues of such matters as have undergone combustion are called cinders in common language, and calces by chemists; and the operation, when considered with regard to these residues, is termed calcination. In this general way it has likewise been applied to bodies not really combustible, but only deprived of some of their principles by heat. Thus we hear of the calcination of chalk, to convert it into lime, by driving off its fixed air and water; of gypsum or plaster stone, of alum, of borax, and other saline bodies, by which they are deprived of their water of crystallization; of bones, which lose their volatile parts by this treatment; and of various other bodies.

This application of the term is nevertheless at present avoided by chemists, who in general consider it as improper, and confine the term to the only class of bodies truly combustible, which leave a large fixed residue after combustion; namely, metals.

When a metallic substance is exposed to a considerable heat with access of respirable air, its external part becomes gradually converted into a calx of a dull earthy appearance, less fusible, and of a less specific gravity, than the metal itself, brittle or friable when cold, and weighing upon the whole more than the regulus which afforded it. The metals called perfect are not calcinable by the heat of common furnaces; and among the semi-metals there are some whose calces are considerably volatile, and rise in the form of flowers. *See METALS*, and also the respective articles of each.

The calcination of metals is indubitably an effect of the same nature as other combustions, and is considered as such by all chemists. But as the theories of

combustion differ, the explanations must vary accordingly. In the ancient theory of Stahl, metals, like other combustible bodies, were considered as compounds of one general principle of inflammability, united to a particular basis in each. This principle, called phlogiston, was supposed to be driven off during combustion, and to leave the bare or metallic calx behind it. Various hypotheses were proposed to account for the increased weight of the calces, which was first truly accounted for by Mayow, who ascribed it to the absorption of air. When modern discoveries had re-established this truth, that the respirable part of the air is absorbed in combustion, the adherents of Stahl found it necessary to modify their doctrine by attributing the extrication of phlogiston to an effect of affinity. In this way the inflammable principle was said to be expelled by the stronger affinity of the air to the calx, at the temperature of the experiment; or otherwise, admitting the matter of heat to have a separate existence, it was supposed to quit the elastic fluid air, at the time of its condensation, and unite with the phlogiston, which was affirmed to make its escape in the flame.

The modern theory of the antiphlogistians, rejecting altogether the existence of a principle of inflammability, ascribes the whole effect to the air which enters into combination. In this a metal is a simple substance, and a calx is a metal united to a portion of vital air.

The calcination of metals is effected by the mere access of the vital air of the atmosphere, provided the temperature be raised to a sufficient height. Nitre greatly accelerates this effect, because it affords vital air by the decomposition of its acid when duly heated. The acids likewise calcine metals without, in general, requiring any external application of heat. Nitrous acid, being more readily decomposed than any other, is accordingly more active in the calcination of metals. In this process the vital air of the acid unites with (and perhaps dephlogisticates) the metal, while the other part of the acid, namely the phlogisticated air, flies off, either alone or in the form of nitrous air. The calx is either dissolved or precipitated, accordingly as it contains a less or greater quantity of vital air; this substance appearing to be the medium of suspension, to which the calx has no tendency if completely saturated.

When vitriolic acid is employed in the calcination and solution of a metal, the part of the acid which flies off is sulphur, more or less acidified, in the form of sulphureous or volatile vitriolic acid. *See* HEAT, PHLOGISTON, METALS, ACIDS, COMBUSTION.

CALX, METALLIC. *See* CALCES, *also* CALCINATION.

CALL. A word used by the miners to denote schoerl or cockle, and also other matters; but Da Costa says that, definitely speaking, it denotes the mineral called wolfram.

CAMELEON MINERAL. The combination of fixed alkali and calx of manganese has been so called, on account of the changes of colour it is subject to when dissolved in water.

CAMOMILE. A small quantity of blue essential oil resides in the cup of the flowers. This colour changes to a brownish green by age, and that more readily in half filled or imperfectly closed vessels than in such as are entirely full. Camomile flowers boiled in wine give it a manifestly saline taste, and the decoction precipitates silver and mercury from nitrous acid. But as the precipitates were different from those afforded by common salt, Neumann, from whom this article is taken, is justly of opinion that the precipitating salt was afforded by the wine.

Sir John Pringle finds, by his experiments, that the soluble part of camomile flowers is one hundred and twenty times as antiseptic as common salt.

CAMPAN MARBLE. The green campan from the Pyrenean mountains is slightly magnetic, and contains, according to Mr. Bayen, in the centenary sixty-five parts mild calcareous earth, thirty-two argillaceous, and three of iron partially calcined. The red campan is not magnetic, and contains eighty-two parts mild calcareous earth, eleven of argillaceous earth, and seven of calx of iron.

CAMPHOR. This singular vegetable substance comes to us from China. There are two kinds grow in the East, the one produced in the islands Sumatra and Borneo, and the other produced in Japan and China. The Sumatran camphor, which the Europeans obtain, is carried to the China market, where it bears a better price than the Japanese. This has given rise to an opinion, that the Chinese buy it to convert it, by some manipulation, into the other. The properties of the camphor we receive render this in the highest degree improbable.

Camphor* is extracted from the roots, wood, and leaves of a large tree, the roots affording by far the greatest abundance. The method consists in distilling with water in large iron pots, serving as the body of a still, with earthen heads adapted, stuffed with straw, and provided with receivers. Most of the camphor becomes condensed in the solid form among the straw, and part comes over with the water. It is said by some to be sublimed without water; but Neumann thinks, perhaps without foundation, that such treatment would give an empyreumatic smell to the camphor. The rough camphor, as imported, resembles crude nitre or bay salt. It is imported in canisters.

The refining of camphor was long a secret with the Venetians, at the time when most of the commodities of the East were brought into Europe by that people. The Hollanders have since appropriated to themselves this, with various other manufactures dependent on chemistry; and I do not find that it is purified in large quantities elsewhere. Neumann mentions one of the largest refineries at Amsterdam, in which were fifty furnaces, all managed by women. He was permitted to see the whole operation, except the charging of the vessels. The sublimation was performed in low flat-bottomed glass vessels placed in sand; and the camphor became concrete in a pure state against the upper part, whence it was afterwards separated with a knife after breaking the glass. Lewis, in a note on this passage, asserts, that no addition is requisite in the purification of camphor; but that the chief point consists in managing the fire so that the upper part of the vessel may be hot enough to bake the sublimate together into a kind of cake. He thinks it more commodious to dissolve the crude camphor in ardent spirit, and, after decantation or filtration, to distil off the spirit, and fuse the camphor into a cake in a glass vessel. Chaptal says the Hollanders mix an ounce of quicklime with every pound of camphor previous to the distillation.

Purified camphor is a white concrete crystalline substance, not brittle, but easily crumbled, having a peculiar consistence resembling that of spermaceti, but harder. It has a strong lively smell, and an acrid taste; is so volatile as totally to exhale when left exposed in a warm air; is light enough to swim on water; and is very inflammable, burning with a very white flame and smoke, without any residue.

The roots of zedoary, thyme, rosemary, sage, the inula helenium, the anemony, the pasque flower or pulsatilla, and other vegetables, afford camphor by dis-

* Neumann by Lewis, ii. 59.

tillation.

tillation. It is observable, that all these plants afford a much larger quantity of camphor, when the sap has been suffered to pass to the concrete state by several months drying. Thyme and peppermint, slowly dried, afford much camphor; and M. Achard has observed, that a smell of camphor is disengaged when volatile oil of fennel is treated with acids. The combination of diluted nitrous acid with the volatile oil of anise afforded him a large quantity of crystals, that possessed most of the properties of camphor; and he obtained a similar precipitate by pouring the vegetable alkali upon vinegar saturated with the volatile oil of angelica.

From all these facts Chaptal concludes that the base of camphor forms one of the constituent parts of some volatile oils, in which it exists in the liquid state, and does not become concrete but by combining with vital air.

Camphor is not soluble in water in any perceptible degree, though it communicates its smell to that fluid, and may be burned as it floats on its surface. It has been observed by Romieu, that small pieces of camphor floating on water have a rotatory motion, which he ascribes to electricity. Ardent spirit, ethers and oils, dissolve camphor very plentifully. The former of these dissolves much more by heat, though when cold it takes up three-fourths of its own weight. The surplus taken up by heat is separated, in crystals of a plumose form, by cooling.

Nitrous acid, which acts so violently on essential oils as to cause inflammation, dissolves camphor without producing heat or agitation. The camphor becomes fluid, and floats on the surface of the acid like oil, and has been called oil of camphor. Neumann says, it combines with the most concentrated part of the acid. The vitriolic acid unites also with camphor, forming a coloured fluid, which at length becomes of a dark reddish brown colour. Other acids also dissolve it. Alkalis precipitate it heavier, harder, and much less combustible.

The addition of water to the spirituous or acid solutions of camphor instantly separates it.

Camphor may be powdered by moistening it with spirit of wine, and triturating it till dry. It may be formed into an emulsion by previous grinding with near three times its weight of almonds, and afterwards gradually adding the water. Yolk of egg and mucilages are also effectual for this purpose; but sugar does not answer well.

When nitrous acid is distilled repeatedly in large quantities from camphor, it converts it into a peculiar acid. M. Kofegarten distilled this acid eight times from it, and obtained a salt in parallelopipedons, which reddened syrup of violets and the tincture of turnsole. Its taste is bitter, and it differs from the acid of sugar more particularly in not precipitating lime from marine acid.

This acid forms, with vegetable alkali, a salt in hexagonal crystals; with mineral alkali, irregular crystals; with volatile alkali, needle-formed and prismatic crystals; and with magnesia, a white pulverulent salt. It dissolves copper, iron, bismuth, zinc, arsenic, and cobalt. The solution of iron affords a yellowish white insoluble powder. With manganese it forms crystals with parallel sides, somewhat resembling basalt.

CANNEL COAL. A coal which burns with a white flame, much smoke, and a smell resembling pitch. It probably owes its name to its use as a substitute for candles in many of the poorer families in the north of England, who in their store of coals take care to be provided with a separate portion of this to be laid on the fire at night. Kirwan says that it breaks easily in any direction, and
in

in its fracture presents a smooth conchoidal surface, if broken transversely. Its specific gravity is about 1.27.

CANTHARIDES. A well known fly with green wings, very common in hot countries, and much used as an article of the materia medica. The powder of this insect applied to the skin causes blisters, excites urine, thirst, and fever. They produce the same effect when taken in a small dose internally. Larger doses have occasioned priapisms, with loss of blood, and lastly death. The ignorant have formerly administered this ingredient to excite venereal emotions, but never without much danger.

M. Thouvenel has made some valuable experiments on cantharides. Water extracts a very abundant principle, which gives it a reddish yellow colour, and also separates a yellowish oily principle. Ether takes up a greenish very acrid oil, wherein the virtue of the cantharides most eminently resides. An ounce of cantharides afforded,

Reddish yellow bitter extract,	-	-	-	-	216 grains.
Yellow oily matter,	-	-	-	-	12
Green oily substance analogous to wax,	-	-	-	-	60
Parenchyma, soluble neither in water nor ardent spirit,					288

The French ounce, 576

Proof spirit, or a mixture of equal parts of water and strong ardent spirit, extracts, by digestion, a tincture from cantharides which possesses all the virtues of the insects themselves. When this tincture is distilled, the spirit which comes over has the smell of the cantharides.

Strong ardent spirit takes up the caustic part only; whence it follows that the intensity of the tincture may be varied, as well by varying the strength as the quantity of the spirit to a given dose of the insects. This tincture has the character of warming and increasing the circulation of the parts to which it may be applied in rheumatic pains, sciatica, the wandering gout, &c.

Neumann was acquainted with the resinous substance of cantharides, and that the virtue of this medicament resided in it.

CAP. The piece which terminates the top of a melting furnace is called the cap. It has the figure of an oblong dome, with a large oval door on one side for the introduction of fuel, of which this furnace requires a quick and large supply. The upper part terminates in a tube or chimney, which may be lengthened accordingly as a greater or less draught is required.

CAPACITY. See **HEAT.**

CAPITAL. The upper part of an alembic, likewise called the head. See **APPARATUS.**

CAPUT MORTUUM. A fanciful term much used by the old chemists, but now entirely rejected. It denoted the fixed residue of operations. As the earlier chemists did not examine these, they did not find any inconvenience in one general term to denote them; but the most slender acquaintance with modern chemistry must shew that it is utterly impracticable to denote, by one general term, all the various matters that remain fixed in certain degrees of heat.

CARBUNCLE. The ancients called all red gems by this name; but the carbunculus of Pliny was the same as the oriental ruby of our jewellers. Its colour is of a deep red inclining to purple. See **RUBY.**

CARDAMOM.

CARDAMOM. Neumann examined the lesser cardamom. One ounce yielded a scruple of essential oil, containing the whole of their pungency and smell, with fourteen or fifteen grains of resinous, and forty-five grains of mucilaginous extract.

CARDUUS BENEDICTUS. Four ounces of the leaves afforded four drams and a half of extract to ardent spirit: the same quantity gave out six drams and a half of mucilaginous extract with water. The expressed juice, depurated and evaporated to the consistence of a syrup, afforded Neumann saline crystals, approaching to the nature of tartar.

CARLINE THISTLE. A prickly thistle, growing chiefly in Switzerland. Neumann speaks of the roots, as brought in bundles from Thuringia. They have a bitter pungent taste, and are chiefly used in the disorders of cattle. In his method of treatment, he obtained by distillation about one ninth part of its weight of essential oil. Ardent spirit extracted more than one fourth of resinous matter, which possessed the flavour and activity of the root. Water extracted a weaker matter.

CARMINE. A red pigment prepared by dissolving cochineal in an alkaline lixivium, and precipitating by alum. It consists, therefore, of the colouring matter of cochineal combined with the argillaceous earth of the alum.

Other precipitates are also called by this name. Lewis asserts, that he has often repeated with success an experiment, first published in the *Acta Naturæ Curiosorum*, in which a fine precipitate, little inferior in beauty to carmine, is afforded by adding the nitrous solution of tin to a decoction of Brazil wood.

CARNELIAN. A stone of the siliceous genus, of different shades of brownish red or flesh colour. The several specimens vary also in their hardness and transparency. The most esteemed is of an orange or yellowish red, and gives fire with steel. The whitish are softer and less valued. Ignition changes the red colour to an opaque white. Its specific gravity is from 2, 6 to 2, 7.

CARPOLITHI. A name given by writers on fossils to such stones as represent fruit. The basis is a martial jasper, in which nodules of rounded calcareous spar and serpentine are included. Denominations of this kind are at present little regarded.

CARTHAMUS, or SAFFLOWER. In some of the deep reddish, yellow, or orange coloured flowers, the yellow matter seems to be of the same kind with that of the pure yellow flowers; but the red to be of a different kind from the pure red ones. Watery menstrua take up only the yellow, and leave the red, which may afterwards be extracted by rectified spirit of wine, or by a weak solution of alkali. Such particularly are the saffron-coloured flowers of carthamus. These, after the yellow matter has been extracted by water, are said to give a tincture to ley; from which, on standing at rest for some time, a deep red fecula subsides, called safflower, and from the countries whence it is commonly brought to us, Spanish-red and China-lake. This pigment impregnates ardent spirit with a beautiful red tincture; but communicates no colour to water. *Lewis on Neumann.*

CASE-HARDENING. Steel when hardened is brittle, and iron alone is not capable of receiving the hardness steel may be brought to possess. There is nevertheless a variety of articles in which it is desirable to possess all the hardness of steel, together with the firmness of iron. These requisites are united in the art of case-hardening, which does not differ from the making of steel, except

in the shorter duration of the process. Tools, utensils, or ornaments intended to be polished, are first manufactured in iron and nearly finished, after which they are put into an iron box, together with vegetable or animal coals in powder, and cemented for a certain time. This treatment converts the external part into a coating of steel, which is usually very thin, because the time allowed for the cementation is much shorter than when the whole is intended to be made into steel. Immersion of the heated pieces into water hardens the surface, which is afterwards polished by the usual methods.

CARYOPHYLLOIDES. A name given to a specimen of mica, the scales of which are concentric and perpendicular. Cronstedt.

CASIA FISTULARIS. The fruit of a tree growing in Egypt and in the East Indies. It is a large cylindrical pod or cane, containing, under an hard rind, a soft pulp lodged in a number of transverse cells, with a flat roundish seed in each. Out of four drams of the dried pulp, Neumann found water take up three drams fifteen grains. Rectified spirit took up as much, or nearly so; but the spirit acted more slowly.

CASIA LIGNEA. The bark of a tree of the same kind as the cinnamon tree. It contains an essential oil of the same flavour and qualities as that of cinnamon; but much less in quantity. Casia is very commonly sold under the name of cinnamon, from which however its external appearance is sufficient to distinguish it. The casia is thick, rough, and breaks cross-wise without splitting; but the cinnamon is smoother, thinner, and cannot easily be broken cross-wise without causing it to split into many thin fragments.

CASTOR. A soft greyish yellow or light brown substance found in four bags in the inguinal region of the beaver. In a warm air it grows by degrees hard and brittle, and of a darker colour, especially when dried in chimneys, as is usually done. No experiments have been made sufficient to shew its component parts with precision. Ardent spirit extracts a resinous matter which colours it; water takes up an abundant mucilaginous principle, and affords by evaporation a saline substance not yet examined.

Castor is regarded as a powerful antispasmodic.

CAT'S EYE. *Pseudopalus*. A semi-opaque stone of the siliceous order, and reckoned among the gems. It is whitish, and reflects green and yellowish rays, varying according to the position of the observer. It is very hard, and is usually cut by jewellers of the figure of a plano-convex lens, and set with the convex side outwards. The best of these stones are very scarce. Bomare informs us that there was one in the cabinet of the Grand Duke of Tuscany, of one inch diameter.

CAUSTIC (COMMON). A fixed alkali deprived of aerial acid and most of its water. If the lixivium of the soap-boilers be evaporated to dryness in a silver or copper vessel, then fused in a crucible, poured out into a basin, and, when solid, cut into small pieces, it forms the common caustic. This must be kept in a closed bottle to prevent its deliquescing.

When a piece of this alkali is applied to the skin, for the space of three quarters of an hour, it corrodes it, no doubt by forming a saponaceous compound with its fat parts. It was much used in making issues, before that practice was laid aside. See **ALKALI**.

CAUSTIC, LUNAR. This is likewise, though improperly, called lapis infernalis. It consists of the crystals of silver obtained by solution in nitrous acid, and afterwards fused in a crucible. To make this preparation, very pure

K k

silver

silver must be dissolved to saturation in nitrous acid, and the crystals separated by evaporation and cooling. These are to be fused in an earthen crucible, sufficiently large to admit of the frothing and swelling that happen at the commencement of the fusion. The heat must be gentle, because the crystals are very fusible, and the acid easily decomposed and driven off. It requires however to be somewhat raised after the ebullition has ceased. As soon as the matter is in quiet fusion, it is to be poured into a mould, consisting of five or six small cylindrical cavities, by which it acquires the form of small pencils, and may conveniently be held in a case instead of touching it with the fingers.

Lunar caustic is black, which seems to arise from part of the acid being driven off, and a portion of the silver revived. Its causticity or action on animal substances appears to depend on the strong disposition of the silver to recover its metallic state, and consequently is a true combustion.

CAUSTICITY. All substances which have so strong a tendency to combine with the principles of organized substances, as to destroy their texture, are said to be caustic. The chief of these are the concentrated acids, pure alkalis, and the metallic salts.

CAWK. A term by which the miners distinguish the opaque specimens of vitriolated ponderous earth, or marmor metallicum. *See* EARTH PONDEROUS.

CEMENT COPPER. Copper precipitated from vitriolic waters by iron. The name is said to be derived from a vitriolic water in Hungary called Ziment.

CEMENTATION. A chemical process which consists in surrounding a body in the solid state with the powder of some other bodies, and exposing the whole, for a time, in a closed vessel, to a degree of heat not sufficient to fuse the contents. Thus iron is converted into steel by cementation with charcoal: green bottle glass is converted into porcelain by cementation with sand, &c. *See* IRON, PORCELAIN.

The effects of cementation appear to be chiefly produced by one or more of the bodies being converted into vapour, and acting upon the others. The change in the solid is chiefly attended to. The powder is called by the name of a cement.

CENTAURY. The leaves of the lesser centaury contain a bitter substance, soluble in water and in ardent spirit. The green colour of the plant resides in the resinous part, being extracted by ardent spirit, but not by water.

CERUSE, or WHITE LEAD. A calx of lead produced by exposing this metal to the vapours of vinegar. To prepare this colour, the lead is cast into plates about one twentieth part of an inch thick, four or five inches wide, and two feet long. These are rolled up in a spiral form, in such a manner that the space of half an inch is left between each revolution. They are then placed in earthen pots which have three projections within, to prevent them from resting on the bottom. Some good vinegar is then poured in, so as to reach no higher than the lower edge of the leaden spiral, and the pots are then buried in dung beneath sheds. A great number of these are disposed beside each other, each pot being covered with a leaden plate and boards, by which contrivance the number of pots is multiplied by placing them above each other in strata. At the expiration of a month or six weeks they are taken out, and the white lead separated by unrolling the coils. It is then ground in mills, and dried in the shade for use.

Some writers distinguish this calx by the name of white lead, and apply the term ceruse to denote a mixture of white lead and chalk.

Lead is found native in the form of ceruse, or the white calx.

CERUSE OF ANTIMONY. A white calx of this semi-metal, which separates from the water in which diaphoretic antimony has been washed.

CHALCEDONY, or WHITE AGATE. A flint of a white colour, resembling milk diluted with water, and more or less opaque, with veins, circles, or spots. It is said to be softer than the onyx, but much harder than the agates of the same colour as the onyx. Bergman observes that it varies greatly in specific gravity; from 2,5 to 4,6. He found the chalcedony of Ferro to contain 84 parts silice, and 16 clay.

CHALK. A very common species of calcareous earth, of an opaque white colour, very soft, and without the least appearance of a polish in its fracture. Its specific gravity is from 2,4 to 2,6, according to Kirwan, who likewise informs us that this substance contains more fixed air than any other variety of the calcareous class; generally about forty per cent. It contains a little siliceous earth, and about two per cent of clay. Some specimens, and perhaps most, contain a little iron, and Bergman affirms that marine salt of lime, or magnesia, is often found in it; for which reason he directs the powder of chalk to be several times boiled in distilled water, before it is dissolved for the purpose of obtaining pure calcareous earth. Sciag. Regni Min. § 92.

CHALK, RED. This is a clay coloured by the calx of iron, of which it contains from 16 to 18 parts in the hundred, according to Rinman.

CHALK, SPANISH. The soap rock, or lapis ollaris, is frequently distinguished by this name.

CHARACTERS CHEMICAL. Language in its usual construction is very far from being capable of expressing our conceptions with the rapidity and perspicuity necessary for the adequate communication of ideas. Writing is still slower and less perfect. But as the language and the writing we possess are capable of supplying our grosser and more immediate wants, it is much to be feared that neither the one nor the other will ever be carried to those degrees of perfection of which they are certainly susceptible. A few attempts have nevertheless been made from time to time; but they have in general been frustrated by the indolence of the multitude, who are at all times more disposed to use a bad instrument than take the trouble to learn the use of a good one. The chemical characters are, in some measure, an instance of this. They were invented by the earlier chemists, probably with no other view than to save time in writing the names of substances that frequently occurred, in the same manner as we avoid repetitions by the use of pronouns. But the moderns seem to have considered them as relics of alchemical obscurity, and have almost rejected their use, without enquiring whether they may not possess advantages far superior to those of the common literal enunciation.

We need not have recourse to the remote field of Chinese literature, to shew how admirably the simplicity, relative position and connection of characters are calculated to express ideas, at one glance of the eye, with a degree of accuracy and precision not to be obtained by the use of many written words. Neither need we recur to the science of algebra, where by the use of characters the mind receives the proof, and assents to propositions almost instantaneously, which would have required a long series of verbal deductions in any other way. Our own science, chemistry, will afford us instances of the most striking nature. The tables at the end of Bergman's Essay on the Affinities exhibit, in the most

speedy and intelligible manner, the greater part of many volumes of chemical results; and I know, from my own experience, that it is easy, by a simple combination of chemical and algebraical characters, to write the whole contents of any chemical work in the small margin usually left by the printer; and that in a manner so full, clear, and perspicuous, that whole pages may be read and understood in a few seconds. This will be readily allowed by any chemist who will make the trial, and will be done with ease by those who are acquainted with the characters and methods of the two sciences; for which reason I hope to be acquitted of the contemptible spirit of reserve, when I say that the limits of the present work, and a wish to pursue the subject a little farther, prevent me from entering into it at present.

Characters are either entirely arbitrary, or they have some resemblance to the idea they represent. The latter property is naturally aimed at, where it can be obtained, because it cannot but tend to assist the memory. Thus a number of dots were used to denote sand or powder; the figure of a retort, to denote the retort, &c. and the combination of characters is used to denote similar combinations of the substances they represent. Very little of system appears in the ancient characters of chemists: the characters of Bergman are chiefly grounded on the ancient characters, with additions and improvements. But the characters of Haffensfratz and Adet are systematical throughout. The two former are exhibited in Plate III, and the latter in Plate IV.

CHARCOAL. When vegetable substances are exposed to a strong heat in the apparatus for distillation, the volatile principles fly off, but combustion does not take place for want of air. The fixed residue is the inflammable substance called charcoal. For general purposes, wood is converted into charcoal by building it up in a pyramidal form, covering the pile with clay or earth, and leaving a few air-holes, which are closed as soon as the mass is well lighted; and by that means the combustion is carried on in an imperfect manner. Common charcoal, when exposed to heat in the distilling apparatus, gives out a small quantity of inflammable air, which seems extraneous to it, or may arise from decomposed water. But if it be burned by admitting vital air into an inverted vessel, the volatile product is found to be fixed air, and nothing but a very small residue of saline and earthy matter remains behind. That the product is merely fixed air, is proved by absorbing it by fixed alkali. The whole either disappears, or the residue consists of vital air as pure as at first*.

From this and similar facts, the antiphlogistian chemists consider the acidification of charcoal, or its conversion into fixed air, or the aerial acid, as a process exactly of the same nature as the acidification of sulphur, or of phlogisticated air, by which the vitriolic and nitrous acids are produced. And as they consider those bases to be simple substances, relative to the state of our knowledge, which become acidified merely by combining with vital air, so likewise they account pure charcoal to be the simple acidifiable basis of the aerial acid, first called fixed air. The phlogistians suppose charcoal to afford inflammable air, which according to them forms fixed air when it meets with vital air, itself being in the nascent state.

Charcoal is black, sonorous, and brittle, and in general retains the figure of the vegetable it was obtained from. If, however, the vegetable consists for the most

* Lavoisier in Mem. Acad. Par. 1781, p. 449.

part of water or other fluids, these in their extrication will destroy the connection of the more fixed parts. In this case the quantity of charcoal is much less than in the former. The charcoal of oily or bituminous substances is of a light pulverulent form, and rises in foot. This charcoal of oils is called lamp-black.

It is a remarkable fact, that well-burned charcoal is a conductor of electricity; though the electric matter is not at all conveyed through wood which is simply baked or deprived of moisture.

Charcoal resists the strongest heat in well closed vessels. If it be ignited, it absorbs elastic fluids with great avidity as it cools; and it retains the property if cooled by immersion in mercury, the absorption being equally considerable when it is afterwards exposed to the air.

The disposition to be burned, which in the ancient theory is supposed to consist in the giving out of phlogiston, and, in the modern theory, in the absorption of vital air, is so great in charcoal that it performs the reverse of combustion in a great variety of instances. Thus it converts the vitriolic acid into vitriolic air by increasing the proportion of sulphur, and it is strongly acted on by the nitrous acid, much nitrous air being extricated at the same time. The rapidity with which nitrous acid acts on dry charcoal has already been mentioned (page 41). In either of these processes, the acid either combines suddenly with the phlogiston of the charcoal, or the vital air of the acid combines with the charcoal itself, considered as a simple substance.

The most violent combustion or detonation of charcoal with nitre, in which the acid is entirely decomposed, may be explained in either way by the two theories. See GUNPOWDER.

Alkalis dissolve charcoal in the dry way, and liver of sulphur unites very readily with it, either in the dry or moist way. All the metallic substances hitherto known are more combustible than charcoal, and consequently are revived or reduced to the metallic state, by being heated with this substance. This, in the ancient theory, denotes that all the metals attract phlogiston more strongly than charcoal does; but in the new theory the effect is ascribed to the stronger attraction of charcoal, which deprives all metallic calces of the vital air which combined with them during their calcination.

An important consequence seems to follow from this circumstance, namely, that there may exist many metallic substances whose combustibility may be greater than that of charcoal, and which consequently are unknown to us as such, because we possess no means of reducing them. Thus the alkalis and earths may consist of peculiar combustible or metallic substances, dephlogisticated or combined with vital air, by an union which the art of chemistry has not yet found means to break.

The residue of charcoal burned in the open air consists of a small quantity of ashes, which contain alkaline and neutral salts. The vegetable alkali is found in the ashes of various plants, and is known under the names of pot-ash, pearl-ash, cendres gravelées, &c. It is not easy to purify it by a cheap process from the neutral salts it may be contaminated with. Mineral alkali is found in the ashes of none but marine plants. The neutral salts found in the ashes of vegetables are vitriolated tartar, Glauber's salt, selenite, common salt, and salt of Sylvius. Calces of iron and manganese, with an earthy substance, compose the insoluble residue. What this earthy substance may be, has not been determined; but it most probably consists of some insoluble earthy salt, such as phosphorated lime.

CHATOYANT.

CHATOYANT. A term applied, by the French, to denote that affection of semi-transparent stones by which their colours vary according to the position of the eye of the observer. We have not a correspondent English word; for which good reason this word has been adopted by several writers on mineralogy.

CHEESE. It is a well known fact, that milk consists of butter, cheese, a saccharine matter called sugar of milk, and a small quantity of common salt, together with much water. Our chemical knowledge of this fluid, before the time of Scheele, consisted of little more than the common operations of the dairy, and the results of the inaccurate method of decomposition by fire. This celebrated chemist, in his Essay on Milk and its Acid, relates a variety of interesting experiments, from which we shall at present extract so much as relates to the caseous part.

If any vegetable or mineral acid be mixed with milk, the cheese separates, and, if assisted by heat, coagulates into a mass. The quantity of cheese is less when a mineral acid is used. Neutral salts, and likewise all earthy and metallic salts, separate the cheese from the whey. Sugar and gum arabic produce the same effect. Caustic alkalis will dissolve the curds, by the assistance of a boiling heat, and acids occasion a precipitation again. It does not appear, however, that the cheesy part is dissolved in milk by means of an alkali, as was ascertained by adding an acid to milk, which ought to have produced a neutral salt, if this had been the case, but did not. The true reason why acids cause the cheesy matter to separate is, that they combine with it, and form a compound much less soluble in water than the cheese itself. Eight parts of water dissolved one part of the curd precipitated by a mineral acid; so much of the acid having been previously mixed with the water as to give it a sour taste. Vegetable acids have very little solvent power upon curds. This accounts for a greater quantity of curd being obtained when a vegetable acid is used.

Scheele thinks that neutral salts, gums, and sugar produce a coagulation of curds by virtue of their stronger attraction for the water.

He considers cheese as an animal gelatinous substance, or rather serous matter. For we would wish to confine the word gelly to such adhesive animal substances as become more fluid by heat, whereas serum coagulates at a certain temperature. He found that curds, after repeated abstractions of nitrous acid, left a white residue consisting of nitrated lime and an animal earth. This animal earth, which may be supposed to be phosphorated lime, amounted to one tenth of the whole weight.

The white of egg, according to this chemist, is nothing else but pure cheese. When this substance is coagulated by means of heat, it may be dissolved by boiling in very dilute mineral acids, which solution is again precipitated by adding some concentrated acid; a phenomenon that likewise happens with the acid solutions of curd or cheese.

CHEMISTRY. It is usual with writers to define the science of chemistry before they proceed to treat on it. It seldom happens, however, that descriptions of very complicated objects can possess that neatness and precision which are essential to a good definition. Chemistry was formerly considered as a mere art, at present it is justly regarded as one of the most sublime and important of the sciences. In its object it embraces the whole of natural phenomena, there being few changes, comparatively speaking, which are not attended with some effect that comes under the consideration of this science. We might define it negatively,

negatively, by affirming that every effect which is not purely mechanical is chemical; and in pursuance of this view of the subject, we should say that chemistry, as a science, teaches the methods of estimating and accounting for the changes produced in bodies, by motions of their parts amongst each other, which are too minute to affect the senses individually; and as an art, we should affirm that it consists in the application of bodies to each other, in such situations as are best calculated to produce those changes.

CHERT or **CHERTZ**. *Petrofilius semipellucidus*, *lapis corneus*, hornstein of the Germans. Chert is a semi-transparent stone of the siliceous kind. It is generally less hard, and of a coarser texture than common flints. Large quantities of chert are found in beds of lime-stone, as flints are found in the beds of chalk; with this difference, that flint consists of loose nodules, and chert often forms large masses of the rock. They are used as grinding-stones for grinding calcined flints and other hard substances, but have too smooth and close a texture for the grinding of corn.

CHRYSOCOLLA. The Greek name for **BORAX**, which see. The ancients likewise used it to denote Mountain Green, *Viride Montanum*.

CHRYSLITE. The oriental chrysolite and peridot are the same gem. It becomes electric by being rubbed: its form is prismatic, of six and sometimes of five striated faces. They are found in the East Indies, Brazil, Bohemia, Saxony, and Spain; in Bourbon and Auvergne in France; and in Derbyshire in England. Some are likewise found with volcanic lavas, as in the Vivarais, where some large lumps have been seen of twenty and thirty pounds weight. But it is remarkable, that some of these chrysolites are partly decomposed into an argillaceous substance.

However, all chrysolites are far from being of the same kind: the oriental ones only differ on account of their green hue, from those sapphires, topazes, and rubies of the same denomination. These do not lose their colour or their transparency in the fire: but the chrysolite either becomes opaque by a strong heat, or is entirely fusible; and it phosphorises in the instant it melts, like the basis of alum and gypseous spar: with borax it produces a thin colourless glass.

Its specific gravity is between 3,600 and 3,700: according to Briffon, and that of the Spanish chrysolite 3,0989.

Its substance is lamellated in the direction of the axis of its primitive form; but the chrysolite from Saxony is foliated in a perpendicular position to the same axis.

The chrysolite of the ancients was the same gem which is now called topaz, and the name of itself indicates that it ought to be so. Pliny very plainly says, (b. 37. c. 9.) that the colour of the chrysolite is yellow like gold.

CHRYSOPRASE. Mr. Achard has made the analysis of chrysoprase from Koseinitz in Silesia, which lost its colour and transparency in the fire, becoming cracked and white in its surface, but without melting. Its powder, either with salt of tartar, mineral alkali, nitre, or borax, gave a diaphanous glass; and with other substances produced opaque masses of different colours.

The chrysoprase is of a green colour, deeper than the chrysolite, but with a yellowish tinge, inclining to blue, like the green leek, as Pliny says (b. 37. c. 8). Mr. Achard says, that it never is found crystallised, and that it is semi-transparent. Mr. Romé de Lisle reckons it amongst the quartz, and says that its colour is owing to the mixture of cobalt, as it gives a fine blue glass when fused with

with borax, or with fixed alkali. But Mr. Achard found the glass of a deep yellow, when the fusion was made with borax; and that it really contains some calx of copper instead of cobalt. Mr. Dutens says, that some gold has been found in this kind of stone: but this last, in all probability, belongs to some other class of substances, viz. to the vitreous spars.

CINNABAR. An ore of mercury, consisting of that metal united with sulphur. This combination is also made by art. The native cinnabar is of different shades, from yellowish to a deep red, and even black. It is found either in hard or friable masses, irregularly figured or crystallized in cubes sometimes, though rarely transparent, and its texture is either radiated, striated, scaly, or granular. One hundred parts contain pretty regularly eighty parts mercury and twenty sulphur. In closed vessels it sublimes by heat, but in open vessels it is decomposed.

The principal cinnabar mines which are wrought in Europe are those of the Palatinate and those of Spain. In the Palatinate the ore is decomposed by mixing it with one third of its weight of lime, and distillation in iron cucurbits one inch thick, three feet nine inches long, one foot wide, with an aperture of five inches. These vessels are disposed in a gallery; forty-eight being arranged in two parallel lines, a second row above the first. An earthen pot is one third part filled with water, adapted to the neck of each cucurbit, and accurately luted on. The gallery is heated by a fire lighted at the two ends, and several apertures, formed in the upper part, serve the purpose of chimneys. The heat is kept up for ten or twelve hours before the process is finished.

The above process was also followed at Almaden in Spain, till the year 1647, when the following was adopted on account of its greater simplicity and economy. The furnace is twelve feet high, and four feet and a half diameter within. At the distance of five feet and a half from the ground is an arched floor, upon which the ore is deposited, and a fire is kindled in the ash-hole. The sublimed mercury escapes through twelve apertures, formed in the upper part of the laboratory. To these apertures rows of aludels inserted one in the other are adjusted, and disposed parallel upon a terrace, which terminates in a small building separated into as many chambers as there are files of aludels. Each chamber has a cavity in the middle, to receive the small quantity of mercury which may arrive to that distance.

Every furnace contains two hundred quintals of cinnabar, and the fire is kept up for three days. The sulphur which burns is disengaged in the form of sulphureous acid, and escapes through small chimneys made in each chamber. Every repetition of the process affords from twenty-five to sixty quintals of mercury.

The mine of Almaden has been wrought from time immemorial. Its veins are from three to fourteen feet in breadth; and their breadth is even larger where they join.

Artificial cinnabar is known in commerce by the name of vermilion, and ought to be used in all cases wherein this compound is meant to be applied to medical purposes, on account of its greater purity. The manufacture of this pigment has long been in the hands of the Hollanders, who kept it a secret; and as there is some difficulty in perfectly succeeding in the process, chemical writers have given various methods of performing it; most of which, according to Mr. Tuckert, are inaccurate. This gentleman has given a full account of the method

method used at Amsterdam, which I find extracted from Crell's Chemical Journal, and inserted in the fourth volume of the *Annales de Chimie*. Its contents are as follow :

The manufactory, at which Mr. Tuckert several times assisted, in the preparation of artificial cinnabar, is without the Utrecht port at Amsterdam, and is one of the most considerable in Holland. Forty-eight thousand pounds of vermilion are annually made in three furnaces by four workmen, besides other mercurial preparations.

The ethiops mineral is first prepared by mixing together 150 pounds of sulphur with 1080 pounds of pure mercury, and then exposing the mixture to a moderate heat in a flat-bottomed polished iron vessel, one foot in depth, and two feet and a half in diameter : its form is that of a chocolate machine. Mr. Tuckert does not enter into the particular manipulations of the Hollanders in this part of the process, because the methods of producing the black combination of mercury with sulphur are well known.

The mercurial ethiops thus prepared is in the next place pounded, in order that it may more readily be put into small earthen bottles, capable of holding each about 24 ounces of water. Thirty or forty of these bottles are filled to be in readiness for the subsequent operation.

In the next place three large pots, or sublimatory vessels, made of clay and very pure sand, are taken. These vessels are previously covered with a coating of lute, which is suffered to become perfectly solid and dry before the vessel is used. Mr. Tuckert refers to a German translation of a work of Mr. Machy for the figure of these vessels, as well as for the composition of the lute. As we have not that translation, it is impossible for us to give any further information on these heads than may be gathered from the rest of his memoir. These pots are placed over three furnaces, upon iron circles. The sublimatory vessels may be of different sizes, and the furnaces are constructed in such a manner as that the flame circulates freely round the vessels to two thirds of their height.

When the vessels are duly placed in their furnaces, a moderate fire is first lighted, which is gradually raised until they become red hot. The fuel is turf, or rather peat, commonly used throughout the United Provinces. As soon as the vessels are red hot, a bottle of the ethiops is poured into the first, another into the second, and another into the third. In the subsequent progress of the operation, two, three, and perhaps more bottles may be poured in at a time ; but this depends on the strength of the inflammation exhibited by the ethiops after its introduction, the flame of which sometimes rises to the height of four, and even six feet. When this is a little diminished, the mouth of the vessel is covered with a plate of iron, one foot square, and an inch and a half thick, which perfectly closes it. In this way, during thirty-four hours, the whole of the prepared matter is introduced into the three pots ; that is to say, for each pot three hundred and sixty pounds of mercury, and fifty of sulphur.

After all the ethiops has been introduced, the fire is duly kept up ; and when the whole sublimation has taken place, it is suffered to go out, which requires thirty-six hours from first to last. The workmen know when the fire is too strong or too weak by the appearance of the flame when the iron cover is taken off : if too strong, the flame rises to the height of several feet ; if, on the contrary, it be too weak, the flame barely appears playing about the edges of the pot. The proper degree of heat is when, upon taking off the cover, a brisk

flame appears, but does not rise more than three or four inches above the opening.

In the last thirty-six hours, the mass was stirred every quarter or half hour with an iron triangle, to accelerate the sublimation. The workmen do this with so much courage, that Mr. Tuckert was every time apprehensive they would fall into the vessels.

When the whole is cool, the vessels are taken out by means of iron circles, which prevent their breaking. The cinnabar is taken out by breaking the vessel. Each vessel constantly affords four hundred pounds of cinnabar, the loss of original weight in each being ten pounds.

The cinnabar does not attach itself to the plates of iron, because they are so frequently taken off, excepting towards the end, when the vessels were left untouched. These plates are not in the least corroded.

The workmen were Germans, and were paid as follows. The foreman, besides his lodging, received twelve guilders a week, which amount to twenty-two shillings and nine-pence of our money; the second received ten guilders, or eighteen shillings and three pence; the third and the fourth received six or seven guilders. They relieve each other night and day, every twelve hours, except holidays and Sundays, so that two men are always at work.

The workmen assured Mr. Tuckert, that they did not remember any accident having happened in the manufactory, though the foreman had been employed for thirteen years; and that, in case of an accident, the whole loss would consist in the broken pot.

These four workmen likewise manufactured on the same premises the corrosive sublimate of mercury, and the red calx called red precipitate. The foreman delivers monthly to Mr. Brand the cinnabar and other products of the manufactory, and receives in exchange sulphur, mercury, martial vitriol, common salt, and nitre.

CINNAMON is the bark of a tree of the bay kind, growing in the island Ceylon, called by Hermann *laurus zeylanicus baccis calliculatis*. Though the bark is one of the most grateful spices, the wood is insipid and inodorous, and used only as firewood: the root is impregnated with aromatic matter, and yields in distillation not only an essential oil, but a portion of camphor. The bark is taken off twice a year; in the spring, before the tree begins to blossom, and in autumn, after the fruit has fallen. It is taken only from young trees, that of the old being woody and bitterish.

It has been observed that the thin membrane, which invests the internal surface of the bark, is vastly stronger in smell and taste than the bark itself. Some suppose that the aromatic matter is originally confined wholly to this membrane, and thence communicated to the exterior parts in drying. Lemery is of opinion that cinnamon receives all its smell and taste from the action of the sun in its exsiccation. This can be no otherwise true, than as the active parts are more concentrated by the dissipation of the watery. Hermann assures us, that it is not in the sun, but in the shade, that the bark is dried.

Cinnamon has a very agreeable pungent, somewhat astringent taste, and a delightful smell. Its essential oil is extremely pungent and fiery, but in small quantity, sixteen ounces of the very best cinnamon scarcely yielding two scruples and a half. The distilled water appears milky, and retains in it greatest part of the oil, which, on long standing, it deposits to the bottom, and then becomes clear.

clear. Oftentimes, though several pounds of cinnamon be committed to distillation, we shall scarcely be able to separate any oil till the water has been kept for some months. Mr. Stoll of Leipsick pretends to have a method of collecting all the oil from the water in a very little time; how justly, I cannot determine. If this should be found practicable, it would be a very useful discovery, provided the oil received no injury. The Dutch, who are masters of the spice islands, are the only persons who prepare the oil of cinnamon in quantity; but it never comes from their hands unadulterated. We seldom meet with oil of cinnamon that holds less than half its weight either of expressed oil or of spirit of wine.

The oil of this spice does not arise in distillation with rectified spirit: on distilling pure spirit from cinnamon, it received no sensible impregnation; on drawing it over repeatedly from fresh parcels of the spice, it smelt and tasted a little, but very weakly. An extract made by spirit contains the whole of the taste and flavour of the cinnamon. The watery extract has nothing valuable; sixteen ounces yield two or more of spirituous extract, and about one and a half of watery.

CIPOLIN. The cipolin from Rome is a green marble with white zones: it gives fire with steel, though difficultly. One hundred parts of it contain 67,8 of mild calcareous earth, 25 of quartz, 8 of silex, 0,2 of iron, besides the iron contained in the silex. The cipolin from Autun contains 83 parts mild calcareous earth, 12 of green mica, and one of iron.

CIRCUMCISION-STONE. A variety of the jade or jaspachates which comes from the Amazon river. It melts by the solar heat into a brown opaque glass, less hard than the stone itself.

CIVET is collected betwixt the anus and the organs of generation of a fierce carnivorous quadruped met with in China and the East and West Indies, called a civet-cat, but bearing a greater resemblance to a fox or marten than a cat.

Several of these animals have been brought into Holland, and afford a considerable branch of commerce, particularly at Amsterdam. The civet is squeezed out, in summer every other day, in winter twice a week; the quantity procured at once is from two scruples to a dram or more. The juice thus collected is much purer and finer than that which the animal sheds against shrubs or stones in its native climates.

Good civet is of a clear yellowish or brownish colour, not fluid, nor hard, but about the consistence of butter or honey, and uniform throughout; of a very strong smell, quite offensive when undiluted, but agreeable when only a small portion of civet is mixed with a large one of other substances.

This commodity is rarely or never to be met with genuine, notwithstanding the sealed bottles in which it is purchased at Amsterdam. Nor have we any certain criteria for distinguishing its adulteration. Some look upon it as genuine, if when rubbed upon paper it sinks in, without leaving any thing upon the surface; and if, when melted in hot water, it totally swims at top: but lard and butter, the substances principally mixed with it, have both these properties equally with the civet itself.

Civet unites easily with oils, both expressed and distilled, but not at all with spirits of wine, nor with water: nor is it rendered miscible with water by the mediation of sugar. Boecler relates, that sugar and rectified spirit are its two

best menstrua; but he has certainly never made the experiment with either. The yolk of an egg seems to dispose it to unite with water; but in a very little while the civet separates from the liquor, and falls to the bottom, though it does not prove of such a resinous tenacity as when treated with sugar and spirit of wine.

It communicates, however, some share of its smell both to watery and spirituous liquors; hence a small portion of it is often added in odoriferous waters and spirits; as those of lilies of the valley, roses, rhodium wood, orange flowers, orange peel, yellow saunders, &c. The Italians make it an ingredient in perfumed oils, and thus obtain the whole of its scent; for oils dissolve the whole substance of the civet. Neumann.

CLAY. *See* EARTH, ARGILLACEOUS.

CLOVES. The pungency of cloves resides in their resin, or rather in a combination of resin with essential oil, for the spirituous extract is very pungent; but if the oil and the resin contained in this extract be separated from each other by distillation, the oil will be very mild; and any pungency which it does retain proceeds from some small portion of adhering resin, and the remaining resin will be insipid. No plant, nor part of any plant, contains so large a portion of essential oil as cloves do. From sixteen ounces, Neumann obtained by distillation two ounces and two drams; and Hoffman obtained from the same quantity an ounce and a half. The oil is specifically heavier than water.

CLYSSUS. A word formerly used to denote the vapours produced by the detonation of nitre with any inflammable substance. It was prepared by using a tubulated earthen retort capable of supporting the sudden application of strong heat, together with a very large receiver, pierced with a small hole. As soon as the bottom of the retort had become red hot, a small quantity, between 60 and 100 grains, of a mixture of nitre and charcoal was thrown into the tube, which was immediately afterwards closed. Detonation of course took place: the elastic product consisting of fixed air from the charcoal, and phlogisticated air from the nitrous acid, escaped for the most part through the perforation: and a small quantity of fluid was condensed in the receiver, consisting either of the mere water of crystallization, or of the same water contaminated with volatile alkali, no doubt produced by an union of phlogisticated and inflammable air.

Other clyffs were also produced, which had their names from the inflammable substance made use of; such as the clyffus of antimony and the clyffus of sulphur, both which, if the materials be duly proportioned, are merely the vitriolic acid air, or sulphureous acid. *See* ACID, VITRIOLIC; also AIR, VITRIOLIC.

COAL. Vegetable coals are commonly distinguished by the name of charcoal, which see. The word coal is with us almost exclusively applied to denote mineral or pit coal. Of this there are many varieties. They appear to consist of petroleum, consolidated with an earth chiefly of the argillaceous kind. This useful substance has been distinguished into many varieties, respecting which much information may be derived from the Mineralogy of Kirwan, or more fully from that of Cronstedt. The legislature, however, distinguish only two kinds relative to the duties payable thereon; namely culm, and caking coal. The former does not consolidate by a kind of fusion into larger masses, when heated, as the latter does, and cannot therefore be applied to such a variety of uses.

Pit-coal is usually found in strata in the earth, almost always in mountains of schistus or grit. It appears to be a general opinion, that this substance owes its origin to the decomposition of vegetable bodies. And indeed, when we attend to the inflammable substances found in the earth, or in the mineral kingdom, we may perceive that very few, and most probably none of them, can be truly said to belong to it, but have been elaborated in the bodies of animals or vegetables. From the turf that is pared from the surface of the earth, and owes its inflammability to the roots of vegetables which are mixed with it, we may descend to the peat, or black earth, of the moors, in many specimens of which vegetable remains are still perceptible; though in most they appear to be deprived of every appearance of their organic texture, their oily and inflammable nature only remaining; and from thence the transition to pit-coal is easy. For if we reflect on the vast revolutions which the earth has certainly undergone through a long course of ages, by means of which its surface has been broken, displaced and inverted, from the actions of floods, earthquake, and the great convulsions of nature caused by volcanic eruptions, it will be no improbable inference that the thin, though extensive strata of pit-coal, as well as the exudations of naphtha, petroleum, and their modifications, have all arisen from the burying of extensive woody tracts of the surface, such as are common in all uncultivated countries. And this probability will be reduced to a certainty when we advert to the natural history of pit-coal which is met with in all the various states of transformation. Whole trees are converted into pit-coal, in such quantities together as to exhibit entire forests; in which the roots, trunks, branches, bark, and even species, are discernible.

Coal pits and slate quarries exhibit innumerable marks of impressions of leaves, and other indications of their vegetable origin; and the analysis of this combustible substance tends still further to confirm this truth. On the other hand, if we attend to such inferences as chemical theory might point out from the facts around us, we shall see how small the probability is, that the mineral kingdom should, after a certain limited time, contain inflammable bodies, if they were not occasionally thrown into it, in consequence of the operations carried on within organized substances. For all inflammable substances, tending to decompose the vital air of the atmosphere, would, in process of time, revert to the class of unflammable bodies, if the operation of organized bodies, particularly of the vegetable kind, did not tend to disengage the vital air again, and render bodies combustible, which were not so when they became parts of those substances.

COATING, or LORICATION. Glass being a brittle substance, and at the same time a bad conductor of heat, is always liable to be broken by the expansion of its outer surface, where heat is so suddenly applied that the expansion of the inner part does not immediately take place. To prevent this, and also to obviate the same inconvenience arising from variations in the intensity of the fire, it is usual to have recourse either to a sand-bath, or to coating the vessel.

Retorts may be coated in the following manner: Take of sand and clay equal parts; make them into a thin paste with fresh blood prevented from coagulating by agitation till it be cold, and diluted with water; add to this paste some hair and powdered glass; with a brush dipt in this mass besmear the retort; and when this first layer is dry, let the same operation be repeated twice or oftener, till the coat applied be about one third part of an inch thick.

Chaptal recommends a soft mixture of marly earth, first foked in water, and then kneaded with fresh horse-dung, as a most excellent coating.

The valuable method used by Mr. Willis of Wapping to secure or repair his retorts used in the distillation of phosphorus, deserves to be mentioned here. The retorts are smeared with a solution of borax, to which some flaked lime has been added, and when dry, they are again smeared with a thin paste of flaked lime and linseed oil. This paste being made somewhat thicker, is applied with success, during the distillation, to mend such retorts as crack by the fire.

COBALT is a semi-metal, of a whitish grey or steel colour, hard and brittle; of a dull, close-grained fracture, and moderate specific gravity. It is rather more difficult of fusion than copper; does not easily become calcined; and its calx is of so deep a blue colour as to appear black. The most remarkable and most valuable property of this metallic substance is, that its calx, when fused with borax, or with alkali and sand, produces a blue glass, known by the name of smalt. The action of air soon tarnishes cobalt; but water has little or no effect upon it.

Concentrated and boiling vitriolic acid, distilled nearly to dryness, combines with this semi-metal. Much vitriolic acid air flies off; and the cobalt is in part calcined, and in part converted into a crystallizable salt, soluble in water, and precipitable by lime and by alkalis in the form of a rose-coloured powder or calx. Diluted vitriolic acid acts upon the calx of cobalt, and forms the same salt.

Nitrous acid dissolves cobalt by the assistance of a moderate heat. Nitrous air is disengaged, and the solution affords deliquescent crystals by evaporation, which do not detonate on ignited coals, but boil up and leave a red calx. Lime and the alkalis precipitate the solution; and, if the alkali be added in excess, it dissolves the precipitate.

The marine acid has scarcely any action on cobalt, unless it be boiling; in which case it dissolves a small portion. It dissolves the calx more readily, with which it forms a red brown fluid, that becomes green when heated. This solution affords deliquescent crystals by evaporation.

Aqua regia dissolves cobalt more easily than the marine, though not so readily as the nitrous acid. This solution is well known as one of the most celebrated sympathetic inks afforded by chemistry. If it be diluted with a sufficient quantity of water to prevent its action upon paper, and then used to write with, the letters are invisible as soon as the clear solution has become dry; but, if the paper be held to the fire for a short time, they appear of a fine green colour; which again disappears by removing it, and suffering it to cool again. If the heat be continued too long after the letters appear, it will render them permanent. This effect seems to be analogous to that which obtains in the marine solution: but none of the efficient causes of change of colour in this, or any other chemical phenomenon, have been hitherto explained.

The acid of borax does not act immediately on cobalt, in the humid way: but borax itself, added to either of the foregoing solutions, effects a decomposition by double affinity; the alkali uniting with the solvent acid, while the acid of borax seizes the cobalt, and forms a scarcely soluble compound, which falls down.

The acid of sugar precipitates cobalt from its solutions, in the form of a pale rose-coloured powder.

Whether

Whether alkalis or earths combine with this metal directly, by the intervention of water, has not been determined.

Cobalt does not act on neutral salts in general. It detonates feebly with nitre, when projected into a red hot crucible, with twice or thrice its weight of that salt. The metal becomes calcined by the action of the nitre; but the changes in both substances require farther examination.

Sal ammoniac is not decomposed by cobalt.

Sulphur does not unite with cobalt but with difficulty. Liver of sulphur combines more readily with it. The action of phosphorus, or its acid, on this substance, remains to be ascertained.

This semi-metal unites by fusion with most of the metals and semi-metals, as has before been noticed. Silver, lead, and bismuth, do not mix with it; and zinc does not but with great difficulty.

Cobalt is found native in alloy with arsenic and iron, and of a steel-grained appearance when broken; or in a calciform state, of a black colour, either pulverulent or indurated; or combined with arsenical acid, in the flowers of cobalt, of a red colour; or, lastly, united to sulphur and iron, with or without arsenic, of various shades of redness. Bismuth, nickel, and other substances are contained in these ores. They may in general be distinguished by solution in aqua regia; with which, after dilution with water, they form the sympathetic ink above described.

The native cobalt, and its calciform or sulphureous ores, may be examined by solution in aqua regia, and evaporation to dryness; after which, the calcined cobalt may be dissolved by vinegar. When this calx is precipitated by mild mineral alkali, the regulus may be accounted for, by allowing one hundred grains for every hundred and sixty grains of precipitate. The other component parts of the residuum, not taken up by the vinegar, may be ascertained by the usual methods. The red arsenical cobalt ore, which contains arsenical acid, may be decomposed by vitriolic acid; and the disengaged arsenical acid will be taken up by highly rectified spirit of wine; after which, the combination of vitriolic acid and cobalt may be dissolved in water, and precipitated by mild alkali: or the ore itself may be dissolved in water, sharpened by an acid; and the calx be then precipitated by the alkali.

In the dry way, the ores of cobalt, after previous pounding, washing, and roasting, may be fused with three times their weight of black flux, in a lined and covered crucible, by the heat of a smith's forge. The tingeing power of cobalt ores may be assayed by fusion with three parts of fixed alkali, and five of powdered flint or glass. The alkali must be put first into the crucible, next the flint, and, above all, the roasted ore. When cobalt ores, containing bismuth, are reduced, this semi-metal usually occupies the lower part of the crucible, and may be separated from it by a blow with a hammer; or at least by eliquation, or melting, on account of its greater fusibility.

Cobalt is found in several parts of Europe, but most plentifully on the southern border of France and in Saxony. The ore is usually broken into pieces about the size of a hen's egg, and the stony parts picked out. The sorted mineral is then pounded in mills, and sifted through wire sieves. By washing in water, the lighter parts are carried off; and the remainder is calcined in a furnace resembling an oven, wherein it is heated by the action of the reverberated flame
of

of wood which plays upon it. In this situation, it is occasionally stirred with long iron rakes; and emits fumes, consisting chiefly of arsenic, which is collected in a long horizontal chimney, built for that purpose. If the ore contains bismuth, this fusible semi-metal is collected at the bottom of the furnace. The cobalt, after a sufficient torrefaction, remains in the form of a dark grey calx, called zaffre. The zaffre of commerce always contains twice or thrice its weight of powdered flints. The flint is pulverized for this and other purposes by means of previous ignition, and quenching in water, which renders it friable. Smalt is a blue glass, composed of one part of the calcined cobalt, fused with two of the flint powder, and one of pot-ash.

The use of this metallic substance is confined chiefly to the production of the blue glass for enamels, and other purposes. Powder and stone blue, used by laundresses, is a preparation made by the Dutch from the coarse smalt.

COCHINEAL was at first supposed to be a grain, but naturalists soon discovered that it was an insect. It is brought to us from Mexico, where the insect lives upon different species of the opuntia. The body of the female is flat on the belly, and hemispherical on the back, and marked with transverse wrinkles. The skin is of a dark brown, the mouth is a tubular point which issues from the side of the thorax; it has six very short brown legs and no wings: the body of the male is rather long, of a deep red colour, and covered with two wings extending horizontally, and crossing a little upon the back: it has two small antennæ on the head, and six legs, which are larger than those of the female; it has not a direct flight, but flutters, hopping very seldom: its life, which is only of a month's duration, terminates by its amours; and the fecundated female lives a month longer, and dies after parturition: the female is sometimes oviparous and sometimes viviparous. The young females when brought forth disperse themselves upon the joints of the opuntia, where they remain fixed by their trunk (trompe) till the end of their life.

Two sorts of cochineal are gathered at Mexico, the sylvestris, there known by the Spanish name grana sylvestra, and the fine, or grana fina, called also mestique, from the name of a province in Mexico, and which are bred upon the nopal. The first is smaller, and covered with a cottony down, which increases its weight with a substance which is useless in dying: an equal weight of it therefore gives less colour, and is of a lower price than the fine cochineal; but these disadvantages are perhaps compensated by its being reared with greater facility, and at less expence, and even by the effects of its down, which enables it better to resist rain and storms.

The coch. sylvest. when bred upon the nopal, loses part of its tenacity, and some of its cotton, and acquires double the size it has on the other species of opuntia. It is therefore to be hoped that it might be improved by a continued attention to the rearing of it, and would approach more and more to the fine cochineal.

M. Thieri de Menonville was led by his patriotic spirit and personal courage to expose himself to imminent danger, in going to observe the mode of rearing the cochineal in Mexico, in order to obtain from thence that valuable production, wherewith he might enrich the colony of St. Domingo. He brought back with him both species of cochineal, and nopals, the kind of opuntia which affords the best food for these insects.

Upon his return, he employed himself in the cultivation of the nopal and different kinds of opuntia, and in rearing the two species of cochineal; but death cut off that excellent citizen, and the fine cochineal soon perished.

When he returned to St. Domingo, he discovered the cochinita sylvestris upon a kind of opuntia called péreschia, or patte de tortue, which grows there. This discovery did not remain unprofitable: M. Bruley employed himself successfully in rearing this species of cochineal; he communicated it to the Cercle des Philadelphes*, who do not lose sight of that object, and have published a posthumous work of M. Thieri de Menonville, which contains very minute instructions with regard to every thing that respects the cultivation of the nopal, and the other species of opuntia that may be substituted for it more or less successfully, for breeding or rearing the cochineal.

Two months after the females, which have been reserved, are sown upon the nopal, the young cochineals are observed to issue from them; and then is the proper season for gathering them: they are killed by immersion in boiling water. The hot iron plates or ovens which are sometimes employed may injure the cochineal by being too hot. When taken out of the water, they are carefully dried by free exposure to the sun. They lose nearly two thirds of their weight in drying.

When the fine cochineal is dry, it must be passed through a sieve sufficiently coarse to allow it to go through, but capable of retaining the down and cotton of the larvæ of the males. These are kept apart and sold separately, or with the cochinita sylvestris.

Fine cochineal, which has been well dried and properly kept, ought to be of a grey colour inclining to purple. The grey is owing to a powder which covers it naturally, a part of which it still retains: the purple tinge proceeds from the colour extracted by the water in which it has been killed.

Cochineal will keep a long time in a dry place. Hellot says, that he tried some one hundred and thirty years old, and found it produce the same effect as new.

The decoction of cochineal is of a crimson colour, inclining to violet.

A small quantity of vitriolic acid made this liquor assume a red colour, inclining to yellow, and a small quantity of a beautiful red precipitate was formed.

Muriatic acid produced nearly the same change in the colour, but no precipitate.

Solution of tartar changed the liquor to a yellowish red. A little precipitate of a pale red colour formed slowly: the supernatant liquor remained yellow; but, on pouring in a little alkali, it became purple. The small quantity of precipitate was quickly dissolved by the alkali, and the solution was purple. Solution of tin formed a rose-coloured precipitate with the yellow liquor.

Solution of alum brightened the colour of the infusion, and gave it a redder hue; a crimson precipitate was formed, and the supernatant liquor retained a crimson colour, somewhat reddish.

Alum and tartar mixed produced a brighter colour, more lively, and inclining to a yellowish red. A precipitate was formed, but much less abundant, and much more pale than in the preceding experiment.

* Now the Royal Society of Arts and Sciences at Cape François.

Solution of tin produced a copious sediment of a beautiful red. The liquor remaining above it was as clear as water, and suffered no change of colour on adding alkali.

Having poured in a solution of tartar, and after that a solution of tin, a precipitate of a rose colour, inclining to black, was formed more quickly than in the foregoing experiment; and, though solution of tin in excess was added, the supernatant liquor remained a little yellow.

Solution of common salt rendered the colour somewhat deeper, but did not make the liquor turbid.

Sal ammoniac gave a purple tinge, without occasioning any precipitate.

Glauber's salt produced no perceptible change in the liquor.

Having boiled a little cochineal with half its weight of tartar, the liquor was more inclining to red, and had a colour much less deep than that obtained from an equal quantity of cochineal without tartar; but the former gave a more abundant precipitate with solution of tin, and its colour was more rosy; so that tartar favours the solution of the colouring part of the cochineal; for, though the colour of the solution is less deep, the precipitate produced from it by solution of tin is of a deeper and more rosy hue. This experiment deserves notice, in judging of the influence of tartar in dying scarlet.

Marital vitriol formed a brown violet precipitate. The supernatant liquor remained clear, with a tinge of *feuille-mort*.

Vitriol of zinc formed a deep violet precipitate. The supernatant liquor remained clear and colourless.

Sugar of lead produced a purple violet precipitate, less deep than the preceding. The supernatant liquor remained limpid.

Vitriol of copper produced a violet sediment, which formed slowly. The liquor remained clear, and of a violet colour.

If the extract which decoction of cochineal affords on evaporation be digested in alcohol, the colouring part dissolves, and leaves a residuum of the colour of wine-lees, of which fresh alcohol cannot deprive it. This residuum, analysed by fire, affords the common products of animal substances.

The alcohol of cochineal leaves on evaporation a transparent residuum of a deep red, which when dry has the appearance of a resin. This also, if distilled, yields the product of animal substances; which shews that the colouring matter is an animal production.

Yet the decoction of cochineal does not easily putrefy. Berthollet has kept some of it more than two months, both in an open vessel and in a bottle corked. At the end of that time the former shewed no signs of putrefaction, the latter had a slight putrid smell. The first grew turbid in a few days, and left a brown violet sediment on the filter: the second preserved its transparency a long time, and probably lost it only from the effect of an incipient putrefaction, or rather of a slight combustion, produced by means of a little vital air, probably united with the red particles of the cochineal. The colour of each had become crimson; but that of the former was more weak, because a greater part of the colouring matter had precipitated, in consequence of the effects produced on it by the air.

A distinguishing characteristic between cochineal and madder may be observed in the manner in which they are acted on by the re-agents. Both receive a yellow colour from acids; but if the colouring matter of cochineal be separated by

by a substance which precipitates it from the acid liquor, it re-appears with its natural colour little altered; whilst that of madder, treated in the same manner, retains a yellow or fawn tinge. Hence mordants abounding in acid, as solution of tin, are much more successfully employed with cochineal than with madder. The cause of this probably is, that the colouring matter of madder united with oxyd of tin retains a portion of acid, whilst that of cochineal combined with it retains none, or a much smaller quantity.—Berthollet on Dying.

COCKLE. A Cornish mineral term applied to various substances, but most generally to the substance called schorl or shirl, from the German, which fee.

COHESION. The power by which the parts of bodies become attached to each other, and form consistent masses. We know scarcely any thing concerning attraction but its effects, there being very few instances indeed wherein we can consider ourselves as authorized to refer this property to any more remote cause deducible by our researches. The various kinds of attraction have been classed relative to their effects, and considered as distinct, and in a certain sense independent properties. It has however been made a question by chemists of undoubted sagacity, whether all attractions, and more particularly the cohesive and chemical attractions, ought not to be referred to one general property of matter, modified by variations in the figures, relative distances, &c. of bodies. *See* ATTRACTION.

COHOBATION. It is frequently required in chemical operations, that a substance should be for a long time boiled, or digested in a volatile fluid considerably heated. This necessarily supposes a great loss of the fluid, if the operation be performed in an open vessel. To prevent this the ancient chemists employed a kind of still, called a pelican. The head of this vessel was provided with two beaks, which by a gradual incurvation returned into the body, and conveyed thither whatever volatile matter had risen into the head, and there became condensed. The views and practices of the moderns do not require these long digestions; but many valuable experiments of Priestley and others, of the nature of repeated distillation, have been made by a simpler apparatus. A glass tube, three or four feet in length, supplies the place of the pelican. A mineral acid water, or any other requisite fluid, is put into the tube, in such a quantity as to occupy an inch or more of its lower end; the upper end is then hermetically sealed, and heat applied to the lower by a sand bath. The fluid partly rises, and is partly changed in other respects by the heat. The vapours as they arrive towards the upper part of the tube become condensed, and return again to the lower in a kind of circulation down the cooler side of the vessel. In this way Scheele has shewn that the pretended conversion of water into earth by repeated distillation, is in fact nothing more than an abrasion or decomposition of the glass vessels; and Priestley has made a variety of experiments on the mineral acids.

COKE. *See* COAL.

COLCOTHAR. The brown red calx of iron which remains after the distillation of the acid from martial vitriol: it is used for polishing glass and other substances by artists, who call it crocus, or crocus martis.

COLD. The privation of heat. *See* HEAT.

COLOPHONY. Colophony, or rosin, is the resinous residuum after the distillation of the light oil from turpentine. It has also the properties

of other resins, and the same principles may be obtained from it by analysis.

COMBINATION. When two bodies unite together in such a manner as that most of the original properties of the bodies respectively disappear, and the compound exhibits new properties not immediately deducible from those before existing, the bodies are said to be combined together. Combination is therefore the most intimate union of bodies, and is to be distinguished from the grosser union called mixture.

COMBUSTION. There is a remarkable distinction in bodies with regard to the effects of heat upon them. Some bodies will admit of being heated to such a degree as even to become luminous or red hot without any permanent or considerable change of their properties or component parts; and as soon as the communication of heat ceases, the bodies immediately begin to cool. On the other hand there are a great number of bodies, which, when heated with access of vital air to such a degree as to become luminous, undergo a change in their properties, inasmuch that their temperature even increases, and they continue to give out heat until the general state of the combination of their parts is changed. These bodies are distinguished by the name of combustible bodies, and the alteration produced by this apparently spontaneous production of heat is called combustion.

It must always have been a problem of the first importance in natural philosophy to ascertain what happens in combustion. The division of substances into combustible and incombustible, is as striking and distinct as any we are acquainted with; and it is a natural inference, that the one class of bodies must possess some general property or identical substance not to be found in the other. The philosophy of the middle ages, probably in consequence of their logical classifications, was much more disposed to attach itself to substances than habits or properties. It is less to be wondered at, therefore, that Beccher and Stahl should have assigned a substance eminently combustible, or fire itself, as resident in all combustible bodies, and occasioning the difference between them and other bodies, instead of enquiring whether the general effect might not have arisen from some effect of the chemical affinities. Modern chemists have however very amply and successfully maintained this last doctrine. Something like party has arisen in the discussion of this great question. It is perhaps the lot of humanity that apathy should attend absolute impartiality, or the absence of prejudice. It is probable that the bigotry of the maintainers of what is now frequently called the ancient chemistry, and the impetuosity of the cultivators of the new, may have occasioned a more complete discussion of the subject, than philosophers whose passions were less animated might have taken the trouble to have made. But there is one evil amongst others which attends the spirit of party, namely, that almost every man of science will be disposed to rank himself on the one or the other side, instead of adhering to that degree of neutrality which the pure facts might otherwise demand. A writer is expected to give an account of his chemical creed, and of course becomes less credible to readers of the opposite party, to which he has not attached himself. And on the other hand, the man who despises party, and keeps his opinion to himself, is supposed to be actuated by fears of the reigning prejudices of the country he lives in; which, if real, would do little credit to his spirit and principles as a defender and propagator of truth. Thus circumstanced like every other chemical writer, decidedly

cidedly averſe to giving up any part of that claim to impartiality which every cultivator of moral or natural philoſophy ought to maintain, and at the ſame time unwilling to pay any compliment to the prejudices either of ancient or modern chemiſts, it appears neceſſary to ſay, that, as far as my knowledge extends, I find the modern or anti-phlogiſtic doctrine much more ſimple in its application to the facts, and conſequently much more probable than the ſyſtem of Stahl: and I believe that any chemiſt, who will take the trouble to acquire the habit of applying the one doctrine as readily as he does the other, will not fail to arrive at the ſame concluſion. After this preface, I ſhall proceed to a ſhort ſtatement of the two doctrines as applied to combuſtion in general.

The modern maintainers of phlogiſton, or the principle of inflammability, do not teach exactly the ſame doctrine as Stahl. This chemiſt ſuppoſed combuſtion to conſiſt in the eſcape of fire from bodies. Various facts have compelled the moderns to modify this poſition. The moſt generally received ſtatement is, that a ſubſtance called phlogiſton, and very ſtrongly attractive of vital air, reſides in all combuſtible bodies; that a certain degree of heat weakens the adherence between phlogiſton and the combuſtible ſubſtance, and conſequently diſpoſes it to a more ſpeedy union with the vital air of the atmophere; that the capacity of vital air for heat is diminiſhed by this union, and conſequently an increaſe of temperature follows, which ſerves to accelerate the diſengagement of more of the phlogiſton; and in this way heat continues to be extricated until the body has become dephlogiſticated, or incombuiſtible.

The modern or anti-phlogiſtic theory is exactly the ſame, excepting that inſtead of ſuppoſing combuſtible bodies to contain a principle of inflammability which attracts the vital air of the atmophere, it infers that the body itſelf attracts and combines with that air; and as no difficulty enſues from this ſtatement, it ſeems clear that the phlogiſton is redundant and unneceſſary in accounting for the effects.

The conſideration of theſe doctrines and their conſequences embraces nearly the whole ſcience of chemiſtry; but the reader may more eſpecially recur to the articles, ACIDS, METALS, PHLOGISTON, and HEAT.

CONCENTRATION. This term is uſed to denote the privation of a part of the water uſually contained in certain fluids, more particularly ſaline ſolutions. Thus, by evaporation of part of the water of a ſolution of ſea ſalt, we obtain a concentrated brine; by evaporation in a nearly cloſed veſſel, or by diſtillation, part of the water of vitriolic acid is driven off, and the remainder is concentrated vitriolic acid. Thus, again, if vinegar be expoſed to freeze, the aqueous part congeals firſt, leaving the concentrated vinegar behind.

CONDENSATION. The approach of the particles of a body to each other, ſo as to cauſe the whole to occupy leſs ſpace than before. It is moſt commonly applied in chemiſtry to denote the tranſition from the vaporous or aërial to the ſolid ſtate, as happens in diſtillation, ſublimation, &c.

CONGELATION. The formation of ice. The term is applied in general to every tranſition from the fluid to the ſolid ſtate. Thus we ſay the congelation of acids of fulphur, of oils, of metals, &c.

CONE, MELTING. This is a hollow cone formed of copper or of braſs, with a handle, and with a flat bottom adjoining to the apex of the cone, upon which it is intended to reſt. Its uſe is to receive a maſs of one or more metals melted together and poured into it. This maſs, when cold, may be eaſily ſhook

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out of the cone from the figure of the vessel. Also if a melted mass, consisting of two or more metals, or other substances not combined together, be poured into this vessel, the conical figure facilitates the separation of these substances according to their respective densities. The cone ought to be well heated before the melted mass is poured into it, that no moisture may be contained, by which a dangerous explosion might be occasioned. It ought also to be greased internally with tallow, to prevent the adhesion of the fluid matter.

CONTRAYERVA. The leaves of this plant are said to afford a poison employed by Indians for poisoning arrows, to which poison the root of the said plant is said to be an antidote. From an ounce of the root, Neumann extracted with water three drams and half a scruple; and from the same quantity with spirit of wine, five scruples and two grains.

COPAL, improperly called gum copal, is a hard, shining, transparent, citron-coloured, odoriferous, concrete juice of an American tree, but which has neither the solubility in water common to gums, nor the solubility in spirit of wine common to resins, at least in any considerable degree. By these properties it resembles amber. It may be dissolved by digestion in linseed oil with a heat very little less than sufficient to boil or decompose the oil. This solution, diluted with spirit of turpentine, forms a beautiful transparent varnish, which, when properly applied and slowly dried, is very hard and very durable. This varnish is applied to snuff-boxes, tea-boards, and other utensils. It preserves and gives lustre to paintings, and greatly restores the decayed colours of old pictures by filling up the cracks and rendering the surfaces capable of reflecting light more uniformly.

COPPER is a metal of a peculiar reddish brown colour; hard, sonorous, very malleable and ductile; of considerable tenacity, and of a moderate specific gravity. At a degree of heat far below ignition the surface of a piece of polished copper becomes covered with various ranges of prismatic colours, the red of each order being nearest the end which has been most heated; an effect which must doubtless be attributed to calcination, the stratum of calx being thickest where the heat is greatest, and growing gradually thinner and thinner towards the colder part. A greater degree of heat calcines it more rapidly, so that it contracts thin powdery scales on its surface, which may be easily rubbed off; the flame of the fuel becoming at the same time of a beautiful blueish green colour. In a strong white heat, nearly the same as is necessary to melt gold or silver, it melts, and exhibits a blueish green flame; by a violent heat it boils, and is volatilized partly in the metallic state.

Copper rusts in the air; but the corroded part is very thin, and preserves the metal beneath from further corrosion.

The vitriolic acid, when concentrated and boiling, dissolves copper. A brown thick fluid, containing calx of copper and a portion of the calx combined with vitriolic acid, is found at the bottom of the solvent. If water be added to this, it forms a blue solution of copper, which by evaporation affords blue crystals, that require about four times their weight of water to dissolve them. This solution lets fall a calx of copper of a green colour by long exposure to the air.

The solutions of copper in vitriolic acid are slightly caustic. Magnesia, lime, and the fixed alkalis, precipitate the metal from them in the form of calx. Volatile alkali precipitates all the solution of copper; but redissolves the calx, and produces a deep blue colour. Copper is precipitable from most of its solutions, in the metallic state, by the addition of iron: a clean plate of iron soon becomes

becomes covered with a coating of copper, when immersed in the solution : hence the volatile alkali and the application of iron are considered as the tests of the presence of copper. There are certain mineral waters in Hungary, Sweden, Ireland, and in various parts of England, which contain vitriol of copper, and from which it is precipitated by the addition of pieces of old iron.

Nitrous acid dissolves copper with great rapidity, and disengages a large quantity of nitrous gas. Part of the metal falls down in the form of a calx ; and the filtrated or decanted solution, which is of a much deeper blue colour than the vitriolic solution, affords crystals by slow evaporation. This salt is deliquescent, very soluble in water, but most plentifully when the fluid is heated. Its solution, exposed to the air in shallow vessels, deposits a calx of a green colour. Lime precipitates the metal of a pale blue ; fixed alkalis of a blueish white. Volatile alkali throws down blueish flocks, which are quickly redissolved, and produce a lively blue colour in the fluid.

Marine acid does not readily dissolve copper, unless it be concentrated and boiling. The solution is of a deep brown colour ; but on standing for some time it deposits a sediment, and becomes green. By careful evaporation it yields crystals ; or when inspissated, it affords a greenish mass, which deliquesces in the air, is readily dissolved in water, gives a green tincture to ardent spirit, melts in a gentle heat, takes fire from a candle, and burns with a blue flame. The marine acid dissolves the calces of copper more readily than the metal itself ; but the solution does not differ from the foregoing.

Vegetable acids dissolve copper slowly ; but in considerable quantity, if respirable air be present. In this, as in a number of other metallic solutions, it appears that the disposition of the air to calcine the metal is greatly assisted by the elective attraction of the acid for the metallic calx. Vinegar does not dissolve copper when boiling, because the steam prevents the access of the air ; but the same acid standing for a day in a copper vessel, will contract a dangerous metallic impregnation. This circumstance accounts for the unhappy consequences produced in some instances by copper vessels, which in other cases have produced no noxious effects. Confectioners boil pickles, and even lemon-juice, in clean copper vessels, without observing any bad taste or noxious consequence to follow. We cannot however avoid heartily concurring in the general opinion which now prevails, in the rejection of copper vessels for culinary purposes.

Verdigris is a calx of copper, prepared in large quantities near Montpellier in France by stratifying copper plates with the husks of grapes which remain after the juice has been pressed out. These soon become acid, and corrode the copper. A solution of this calx in distilled vinegar affords permanent crystals, improperly called distilled verdigris.

Fixed alkalis have some action on copper, with which they form a light blue solution. This, as well as the volatile alkaline solution, appears to succeed better in the cold than by the assistance of heat, for the same reason as the cold acetous acid acts upon copper ; namely, the facility with which the metal is calcined by the access of air.

Volatile alkali dissolves copper with much greater rapidity than fixed alkalis, whether it be in the metallic or calciform state, and forms a beautiful blue solution. This fluid has long attracted the notice of chemists, on account of its becoming colourless in closed vessels ; and recovering its colour, which gradually extends from the surface downwards, when the vessel is opened. This effect

effect is explained by the supposition, that the perfect solution of calx of copper in volatile alkali is colourless when the alkali is in excess; but that it is blue when it abounds with calx of copper: and accordingly it is found that the loss of colour on keeping the vessel closed for some time, and its re-appearance on opening the vessel, do not succeed with old solutions, which are permanently blue.

The air calcines more perfectly a portion of the suspended copper, which gives a blue colour to the fluid until it has more intimately combined with the alkali. If this combination be made in the closed vessel, the colour disappears; if it be made in the open vessel, the calcination of another portion goes on, and continues until the alkali is saturated, and can combine with no more: so that the last portion of perfect calx, which causes the blue colour, does not seem to have entered into so intimate a combination, for want of an excess of alkali. The alkali does not take up any considerable quantity, when applied to copper filings; but it dissolves much more of the calces of copper. The solution does not very readily afford crystals.

Oils do not seem to act upon copper until they become rancid, in which case their disengaged acid corrodes the copper, and the oil assumes a blueish green colour. Verdigris is soluble in ardent spirit. Copper, in the metallic state, does not unite with earths or alkalis in the dry way. Its calces enter into the composition of glasses. In general it does not act on the neutral salts by fusion. Nitre detonates with it but difficultly. Filings of copper are thrown upon red hot nitre; and the residue is a brownish grey calx, mixed and partly combined with vegetable alkali. If this be washed with water, the remaining calx may be fused without other addition into a deep opaque brown glass, used by enamellers.

Sal ammoniac is decomposed by copper filings. The produce which comes over consists of caustic volatile alkali, rendered blue by a small portion of copper, together with alkaline air, inflammable air, and phlogisticated air: the residue consists partly of marine salt of copper and calx. In this experiment we find that the copper detains the acid; while the volatile alkali being set at liberty comes over into the receiver. The inflammable and phlogisticated air cannot so clearly be accounted for, as they may arise either from part of the alkali being decomposed into its first principles, or the inflammable air may be supplied during the solution of the copper; in which case it will proceed from the phlogiston of that metal, according to the hypothesis of Stahl; or from a decomposition of part of the water of crystallization of the sal ammoniac; the pure air of which will be communicated to the copper, in order to calcine and render it soluble in the marine acid, while its inflammable air comes over in the elastic state.

A solution of alum boiled in a copper vessel deposits some earth, and the fluid exhibits signs of the presence of copper by the test of volatile alkali. This does not seem to be a perfect decomposition of the alum; but appears to be effected by virtue of the acid, which that salt contains in excess. The neutral salt or alum saturated with its own basis falls down, because less soluble; while the excess of acid, forming vitriol of copper, exhibits the blue tinge when volatile alkali is added.

Copper unites very readily with sulphur. If copper filings be mixed with flowers of sulphur and a little water, the combination takes place; but it is much more readily effected in the dry way. This cannot be done by direct fusion, because

because the sulphur is burned at a much less heat than is required to fuse the copper. It may be prepared by mixing equal parts of sulphur and copper filings together, and exposing them to heat gradually raised to ignition : or plates of copper may be stratified in a crucible with sulphur, and gradually heated as before. This compound is a blackish grey mass, and is used by dyers and callico printers : it is distinguished by the name of *æs veneris*. Liver of sulphur dissolves copper both in the humid and dry way.

Phosphorus unites with the calx of copper; or if the phosphoric glass be exposed to heat in a crucible, together with its weight of copper filings and about one quarter of its weight of charcoal, the phosphorus which is formed combines with the copper, and forms a kind of pyrites, which changes by exposure to air. It loses its metallic state, and assumes a black colour.

This metal combines very readily with gold, silver and mercury. It unites imperfectly with iron in the way of fusion. Tin combines with copper, at a temperature much lower than is necessary to fuse the copper alone. On this is grounded the method of tinning copper vessels. For this purpose, they are first scraped or scoured; after which they are rubbed with sal ammoniac. They are then heated, and sprinkled with powdered resin, which defends the clean surface of the copper from acquiring the slight film of calx which would prevent the adhesion of the tin to its surface. The melted tin is then poured in, and spread about. An extremely small quantity adheres to the copper; which may, with great justice, be supposed insufficient to prevent the noxious effects of the copper as perfectly as might be wished.

When tin is melted with copper it composes the compound called bronze. In this metal the specific gravity is always greater than would be deduced by computation from the quantities and specific gravities of its component parts. The uses of this hard, sonorous and durable composition in the fabrication of cannon, bells, statues, and other articles, are well known. Bronzes and bell-metals are not usually made of copper and tin only, but have other admixtures, consisting of lead, zinc, or arsenic, according to the motives of profit, or other inducements of the artist. But the attention of the philosopher is more particularly directed to the mixture of copper and tin, on account of its being the substance of which the speculums of reflecting telescopes are made. See SPECULUM.

Copper unites with bismuth, and forms a reddish white alloy. With arsenic it forms a white brittle compound, called tombac. With zinc it forms the compound called brass, and distinguished by various other names, according to the proportions of the two ingredients. It is not easy to unite these two metals in considerable proportions by fusion, because the zinc is burned or volatilized at a heat inferior to that which is required to melt copper; but they unite very well in the way of cementation. In the brass works, copper is granulated by pouring it through a plate of iron, perforated with small holes and luted with clay, into a quantity of water about four feet deep and continually renewed : To prevent the dangerous explosions of this metal, it is necessary to pour but a small quantity at a time. There are various methods of combining this granulated copper, or other small pieces of copper, with the vapour of zinc. Calamine, which is an ore of zinc, is pounded and mixed with the divided copper, together with a portion of charcoal. These being exposed to the heat of a wind furnace, the zinc becomes revived, rises in vapour, and combines with the copper, which it

converts into brass. The heat must be continued for a greater or less number of hours, according to the thickness of the pieces of copper, and other circumstances; and at the end of the process, the heat being suddenly raised causes the brass to melt, and occupy the lower part of the crucible. The most scientific method of making brass seems to be that mentioned by Cramer. The powdered calamine, being mixed with an equal quantity of charcoal and a portion of clay, is to be rammed into a melting vessel, and a quantity of copper, amounting to two thirds of the weight of the calamine, must be placed on the top, and covered with charcoal. By this management the volatile zinc ascends, and converts the copper into brass, which flows upon the rammed clay: consequently, if the calamine contain lead, or any other metal, it will not enter into the brass, the zinc alone being raised by the heat.

A fine kind of brass, which is supposed to be made by cementation of copper plates with calamine, is hammered out into leaves, in Germany; and is sold very cheap in this country, under the name of Dutch gold. It is about five times as thick as gold leaf; that is to say, it is about one sixty-thousandth of an inch thick.

If brass be kept in a state of ignition, with contact of air, the zinc burns, and the copper remains. Whether the zinc would quit the brass without combustion, is not known; though there is little doubt but it might be driven off in close vessels.

The quantity of zinc, in good brass, is about one third of its weight.

Copper unites readily with regulus of antimony, and affords a compound of a beautiful violet colour. It does not readily unite with manganese. With wolfram it forms a dark brown spongy alloy, which is somewhat ductile.

Copper is either found native, mostly in an impure state, or in the form of a calx, of a red, green, or blue colour. The native solutions of copper frequently impregnate calcareous earths, in which they deposit the metal. The turquoise stone is the tooth of an animal, penetrated with the blue calx of copper. Many ores of copper contain sulphur. Among these, the vitreous copper ore is of a red, brown, blue, or violet colour; sometimes crystallized, but usually soft enough to be cut with a knife. Some of the pyrites contain a considerable proportion of copper, together with iron, sulphur, and clay. The grey copper ore is a sulphureous combination containing arsenic; it is of a white, grey, or brown colour, heavy, and difficult of fusion. Blendore copper ore is of a brown colour, hard, solid, compact, and granulated: it contains the metal, with sulphur, arsenic, zinc, and iron. Some slates, and one species of coal, afford copper; and several waters contain this metal, dissolved in vitriolic or marine acid.

Native copper may be assayed, in the humid way, by solution in nitrous acid. If it contain gold, this metal falls untouched to the bottom, in the form of a black powder; if silver, it is soon precipitated by more copper; if iron, by boiling the solution for some time, it is gradually calcined, and falls to the bottom.

The calciform copper ores are soluble in acids, and may be precipitated either by iron, which affords the copper in the metallic state, or by mild alkali, which throws down 194 grains of precipitate for every 100 grains of copper.

Sulphureous copper ores may be powdered, and gently boiled to dryness in five times their weight of concentrated vitriolic acid. The whole, or most part of the sulphur, flies off by this heat. The vitriolic salt of copper requires at least

least four times its weight of water to dissolve it. A sufficient quantity being therefore added, and a polished iron plate boiled in the solution, the copper will be precipitated. If iron be found to be mixed with the precipitate, it must be again dissolved, to obtain a richer solution. This will deposit pure copper, if the operation be conducted as before. If it contain other metals, they may be easily separated by solution in nitrous acid.

In the dry way, the sulphureous ores of copper must be first pulverized, and separated as much as possible from the earthy and stony particles, then roasted, to separate the sulphur and arsenic; and lastly, melted with an equal weight of M. Tillet's flux, which consists of two parts pounded glass, one calcined borax, and one eighth of charcoal. More borax may be added if the ore be poor. Alkaline fluxes are hurtful in the fusion of copper ores, because the salt combines with the sulphur, and forms hepar, which dissolves part of the copper.

In the large way copper is roasted in a close furnace, by a slow fire, to scorify the mixtures of iron and other substances. By repeated fusions with sulphur and charcoal, the scorified metal rises to the top, and is skimmed off. The copper, in the great Hungarian mines, is said to undergo fusion fourteen times before it is fit for sale. The roasted ore in the isle of Anglesey is deprived of its vitriolic salt by washing, and the copper is precipitated by means of old iron immersed in the water. This precipitated copper is however but small in proportion to the whole produce.

Copper is found in various parts of the world; in Spain, France, England, Norway, Hungary, Sweden, and elsewhere. The Japan copper is said to be purer, and has a greater specific gravity, than any other copper. The wire-drawers, who require copper of extraordinary ductility, use the Swedish copper. The copper mines in England are exceedingly numerous and productive. Paris Mountain, on the isle of Anglesey, contains a bed of ore forty feet in thickness, and is said to produce upwards of four thousand tons of copper annually.

The uses of this metal are too numerous to be distinctly specified. It has for some years past been applied with great success and advantage for sheathing the bottoms of ships; and several builders have lately endeavoured to introduce it as a covering for houses. It is the lightest of all coverings; but whether it be more durable than slate, which is nearly as light, has not yet been ascertained by experience.

COPPERAS. Martial vitriol is called green copperas in commerce. The vitriol of copper is called blue copperas, or frequently blue vitriol; and the vitriol of zinc is called white copperas.

CORAL and **CORALLINE** are shells of marine animals of the polypus kind, and possess the same chemical properties as the shells of oysters and other fish; that is, they consist of calcareous earth combined with mucilage and other animal matter.

CORK is a bark of a tree of the oak kind, very common in Spain and the other southern parts of Europe. By boiling in water Neumann obtained from cork one twelfth part of its weight of extract, and by digestion in ardent spirits he obtained rather a larger quantity of resinous matter.

Mr. Brugnatelli * has examined this substance in the more accurate methods

* The Journal de Physique for August 1787 is now before me, containing an extract of the author's paper, from Crell's Annals for the same year.

of modern chemistry. The cork upon which he made his experiments was white and very smooth. In the focus of the burning glass it was quickly burned with a white brilliant flame, leaving a light spongy coal, easily and almost totally consumed in a crucible, the residue of ashes being scarcely perceptible. Cork, when treated in the way of destructive distillation, was entirely or very nearly converted into inflammable air. Boiling water only softened it. The action of the vitriolic and also of the marine acid, even when assisted by heat, was scarcely sensible.

But on the contrary the mere vapours of fuming nitrous acids acted upon it, and reduced a portion into a coarse yellowish and evidently saline powder. Mr. Brugnatelli was induced from this observation to distil them together. He put half an ounce of cork, grossly powdered or rasped, into a tubulated retort, and poured upon it four times its weight of fuming nitrous acid. The acid soon became of a deep yellow colour, which it communicated to the cork, while the retort by degrees became filled with red vapours produced by the disengagement of a large quantity of nitrous air. After the distillation there remained a yellow viscid and very acid matter.

This residue was for the most part soluble in water; the insoluble portion being probably that which had escaped the action of the nitrous acid. The solution was yellow, strongly reddened blue vegetable colours, and had an acid though bitterish taste. By evaporation of the water and repose in a cool place, the acid again became changed into a thick viscid matter resembling wax, and capable of being kneaded between the fingers.

This acid is soluble in ardent spirit, to which it communicates a yellow colour, inclining to green. Upon ignited coals it does not take fire, but emits a disagreeable smell like burned wood, at the same time that it becomes converted into coal, and at last into dark-coloured ashes. The acid of cork unites with all the alkalis and earths. With the mild vegetable alkali it effervesces, and forms a thick deep yellow mass, which crystallizes by cooling. This mass is soluble in water, and in the three ancient mineral acids, but not in vinegar or ardent spirit.

Like the acid of sugar, this acid exhibits a peculiar affinity to lime. It likewise acts upon metallic substances.

CORK, FOSSIL, (SUBER MONTANUM). This name is given to a stone which is a species of amianthus, consisting of flexible fibres loosely interwoven, and somewhat resembling vegetable cork. It is the lightest of all stones. By fire it is fusible, and forms a black glass. It possesses the general properties of amianthus.

CORO-SHUT MARLE. A kind of marle of a brown colour mixed with chalk and blue veins.

CORROSIVE SUBLIMATE. A combination of mercury with dephlogisticated or aerated marine acid. See MERCURY.

COUNTRIES. An English mine term for the sides or enclosures of a vein or load of ore: *e. g.* the country of the lead is limestone, killas, &c. &c.

CREAM OF LIME. When lime water is exposed to the air, a portion of aerial acid or fixed air combines with the lime near the surface, and converts it into chalk, or mild calcareous earth, which first forms a pellicle at the top, and afterwards falls down. This substance, which is either not at all soluble in water,

or

or much less so than lime, is separated on that account. The term is at present seldom met with.

CREAM OF MILK. A portion of milk which rises to the surface of the fluid by repose: most probably in consequence of an incipient fermentation. It contains all the butter, some of the cheese, together with a portion of the other principles of the milk. *See BUTTER and MILK.*

CREAM OF TARTAR. The salt called cream of tartar, and crystals of tartar, consists of tartar purified by the usual chemical methods. This manufacture is chiefly carried on at Montpellier, and at Venice. The object to be accomplished consists in depriving the crude tartar of an abundant mucilaginous principle.

The following is the process used at Montpellier, as given by Chaptal. The tartar is dissolved in water, and suffered to crystallize by cooling. The crystals are then boiled in another vessel, with the addition of five or six pounds of the white argillaceous earth of Murviel to each quintal of the salt. After this boiling with the earth, a very white salt is obtained by evaporation, which is known by the name of cream of tartar.

M. Defmaretz has informed us (*Journal de Physique* 1771) that the process used at Venice consists, 1st, in drying the tartar in iron boilers; 2dly, pounding it and dissolving it in hot water, which by cooling it affords purer crystals; 3dly, redissolving these crystals in water, and clarifying the solution by whites of eggs and wood ashes.

The process of Montpellier is preferable to that of Venice. The addition of the ashes introduces a foreign salt, which alters the purity of the product.

Cream of tartar crystallizes in tetrahedral prisms cut off slantwise.

This salt is used by the dyers as a mordant; but its greatest consumption is in the north, where it is used at table as a seasoning.

CRIMSON. *See DYING.*

CROCUS. The yellow or saffron-coloured calces of iron and copper have been called *crocus martis* and *crocus veneris*. These terms are now seldom met with in the writings of philosophical chemists, though they still are retained in various dispensaries.

CRUCIBLE. A pot or vessel formed either of earth, of plumbago, or of some suitable metal. It is used for fusions, cementations, and other operations in the dry way. *See APPARATUS.*

CRYSTAL. This word is used extensively to denote those portions of bodies which have assumed a symmetrical form at the time of acquiring the solid state. Thus we have crystals of salts, of metals, of earths, and of every other substance that possesses a considerable degree of simplicity in its composition. It is likewise used as the name of various substances to which we shall proceed.

CRYSTAL, FACTITIOUS. The very fine clear glasses made in imitation of precious stones, are sometimes called factitious crystals, but much more commonly pastes. Our opticians and other artists distinguish the dense white glass, which contains much calx of lead, by the name of crystal glass, and frequently enough by that of white flint. *See GLASS.*

CRYSTAL, MINERAL. In the ancient dispensaries we find a formula for making a salt under this name, by fusing nitre, projecting a little sulphur thereon, and afterwards casting it into cakes. It is not necessary to give any detail of the imaginary advantages supposed to be obtained by treating nitre in this manner. The crystal mineral will vary according to the management. Part

of

of the nitrous acid may be decomposed by the heat, and part will be decomposed by the detonation. The sulphur will be acidified, and will combine with the portion of disengaged alkali. The crystal mineral will therefore consist of nitre contaminated with a small quantity of vitriolated tartar, and is not worth the trouble of making, because pure nitre will answer every medical purpose to which this might be applied.

CRYSTAL, ROCK. The purest specimen of siliceous earth. This is either colourless and crystallized in hexagonal pyramids, and then called mountain crystal, or in various other forms. Its specific gravity is from 2,65 to 2,7. Its texture lamellated, and frequently shattered. The application of heat, unless extremely gradual, causes it to crack and lose its transparency. Some of these crystals have been found to consist of pure siliceous earth. Bergman extracted about six of argillaceous, and one of calcareous earth, from the 100 parts of these crystals. The most violent heat of a furnace has not been found to diminish the weight or hardness of rock crystal; but professor Errhmann fused it by flame, urged with a stream of vital air.

The formation of crystal has much engaged the attention of chemists. There seems to be little doubt that this earth is suspended in water, most probably, by a true solution, and afterwards deposited in the same manner as other soluble bodies are: the only peculiarity appears to be, that so very large a quantity of the water is required to suspend a small quantity of the earth, that this last has eluded the attention of philosophers. The effects of water in the extensive operations of nature, relative to this earth, are however very considerable. The vast basin chiefly composed of siliceous materials deposited by the water of the prodigious fountain of Geyser, in Iceland, described by Vontroil, affords a proof that hot water suspends siliceous earth, and points out a series of experiments to be made with Papin's digester, though not yet undertaken by any one. And the observations of Mr. Genflane, quoted by Chaptal in his Elements of Chemistry, with others of the professor himself, prove that rock crystal is formed in a way not at all differing from that of calcareous spars. Mr. Genflane shews that a quartzose gurf is formed by simple transudation upon ferruginous rocks, and the same naturalist has taken notice that when the gurf is worn and deposited by water, rock crystals are formed. The waters which work their way through the quartzose rocks of the mine of Chamillat, near Planche les Mines in Franche Comté, form quartzose stalactites to the roof of the works, and even upon wood. The extremities of these stalactites, which have not assumed a solid consistence, are of a granulated and crystalline substance, easily crushed between the fingers.

In these cavities, called craques by the miners, a fluid gurf is often found, and still oftener crystals ready formed. Chaptal observed at Saint Sauveur, in the work of Laboissiere near Bramebiaou, several incrustations of gurf on the side of the gallery; and these spreading incrustations were terminated by well-formed crystals, wherever the wall overhung, or deviated from the perpendicular. This gurf, when handled, and minutely examined, had no other appearance than that of a siliceous paste of considerable purity.

Bergman obtained crystals resembling rock crystal, but not so hard, by dissolving siliceous earth in the acid of spar, and leaving it to spontaneous evaporation. Chaptal has observed a fact of the same nature. Mr. Achard obtained a crystal as hard and as transparent as rock crystal by dissolving the earth of alum

alum in water impregnated with fixed air, the fluid filtrating very slowly through the bottom of a porous vessel of baked clay. A crystal of this kind was sent by him to my late friend Mr. Magellan, who exhibited it to the Royal Academy of Sciences at Paris, in the year 1778; and from whom I received it, and still retain it in my possession. Others have since attempted to repeat the experiment, though without success; and there have not been wanting several writers who have questioned the validity of the fact, though in my opinion very rashly; the character of this chemist, and the obscurity of the subject, in which so many unheeded circumstances might have conspired either to produce or vary the results, being amply sufficient to defend him from any imputation of so degrading a nature. It has been thought in particular, that a very perfect state of repose is necessary for the success of this experiment of a crystallization so extremely slow; and indeed if it be considered how greatly the phenomena of crystallization are influenced by the slightest agitation, and at the same time how considerable the agitations of the grounds and buildings are in great towns, it will not appear at all wonderful that the Parisian chemists should not have succeeded in attempting to repeat this experiment. Any one may satisfy himself as to these vibrations, by observing the reflection of objects in a basin of mercury, which, however defended from the impressions of the external air, does not remain a moment in tranquillity, unless at a very great distance from all workshops or roads where carriages pass.

Since that time Mr. De Morveau having inclosed rock crystals with a bar of iron in a bottle filled with gaseous water, perceived a vitreous point fixed to the iron, which he supposed to be a rock crystal formed by this operation; so that he considers iron as a necessary intermedium to enable the carbonic acid to dissolve quartz.

Rock crystal, though the softest among transparent stones, is harder than most of the opaque stones, and much harder than glass.

CRYSTALLIZATION. Whenever the parts of bodies are separated from each other, and suspended in a medium or solvent, in which they can freely move, they either remain at a distance from each other by virtue of their attraction to the solvent, or they come together by their own mutual attraction, and form consistent masses. See *ATTRACTION*.

From the facts there appears to be just ground to conclude that the particles of bodies demand certain relative positions at like distances, in order that the energy of their attraction may be the greatest possible; in a manner similar to what we observe in the attractions of magnetism and electricity. This polarity of the particles deducible by mathematical reasoning from their supposed figures, but no doubt in a great measure dependent on their component parts likewise, will cause the aggregate masses to assume some determinate figure, in similar circumstances or situations, and this figure will be modified in a great variety of ways accordingly as those circumstances are changed. If the particles are suspended or kept fluid, either by a due quantity of solvent, or by heat, or by both of these agents, a separation will ensue, whenever the quantity of the solvent or of the heat is diminished. If this diminution be sudden, it will be attended with a considerable share of intestine motion, by which the particles must be irregularly moved, and will eventually come together with such sides or faces presented to each other, as might not have been presented if the irregularity of motion

motion had not interfered. In such cases the particles will form a solid, possessing little or no symmetry in its figure. This is called confused crystallization.

On the other hand it may happen, that by gradual evaporation, or cooling, the diminution of the quantities of solvent, or of heat, may take place so slowly as to occasion a degree of motion altogether inconsiderable among the parts of the fluid. In this case, the particles which are about to separate will approach each other with extreme slowness, and no circumstance will interfere to prevent their applying such sides or faces towards each other as are best adapted to the governing laws of attraction. As soon as the particles have arrived to a distance less than is sufficient for their mutual attraction to overcome the power of the fluid which suspends them, they will rush together, and form symmetrical bodies possessing figures originating in, and dependent on the properties or nature of the particles which form them, and the symmetry will be more perfect the less the crystallization is influenced by disturbing causes. This is called regular crystallization, and the symmetrical bodies are called crystals.

As the agitation arising from the causes just mentioned is sufficient to prevent the regular formation of crystals, so likewise it is found that mechanical agitation is still more destructive of their regularity. Slow crystallization produces sugar candy; a quicker crystallization affords loaf sugar. When a balloon some years ago was inflated at Moorfields by inflammable air, extricated by the action of vitriolic acid upon zinc, the white vitriol of commerce was afforded in beautiful transparent crystals, which the shopkeepers refused to purchase; but when by subsequent solution and mechanical agitation, a white mass of confused crystals was obtained, the shopkeepers recognized the *white copperas* they had been used to deal in. The presence or absence of external impulse is of so much consequence in crystallization, that it may be doubted whether the action of light, which considerably impedes the formation of regular crystals, may not be attributed to this cause.

The permanent texture of bodies, their fracture, and other like circumstances, appear to depend upon the state of crystallization at the time of assuming the solid form. In metals, for example, the crystals are smaller and more confused the hastier the cooling. Thus steel suddenly cooled breaks with a granular fracture, possesses a diminished specific gravity, and is very hard, whereas the same steel, more slowly cooled, will be denser, softer, difficult to be broken asunder, and when broken exhibits a very different internal texture. The crystals of other metals may be obtained by fusing them in a crucible with a hole in its bottom closed by a stopper, which is to be drawn out after the vessel has been removed from the fire, and the surface of the metal has begun to congeal. The same effect may be observed if the metal be poured into a plate or dish, a little inclined, which is to be suddenly inclined in the opposite direction, as soon as the metal begins to congeal round its edges. In the first method, the fluid part of the metal runs out of the hole, leaving a kind of cup lined with crystals: in the latter way the superior part, which is fluid, runs off, and leaves a plate of metal studded over with crystals.

There is scarcely any experiment in chemistry which does not afford some appearance of a curious nature, referable to crystallization.

When bodies dissolved in any fluid are separated by crystallization, they are always found to retain a part of the fluid. The water thus retained by saline crystals

crystals is called the water of crystallization. This water appears to be essential to the transparent crystalline form of salts, and is no doubt retained by virtue of their attraction for that fluid. From some experiments, in which a much greater degree of cooling was produced by the solution of crystallized soda than of such as had lost its water of crystallization, it may be inferred that this water exists in crystals in the congealed or solid state, and perhaps much denser than mere ice. Most salts may be deprived of their water of crystallization by mere heat. Some lose it in the common temperature of the atmosphere, and fall into a pulverulent mass, called an efflorescence. Other salts attract water so strongly that they draw it from the atmosphere, and gradually become fluid, a phenomenon distinguished by the name of deliquescence. Mr. Baumé affirms that the water of crystallization in all neutral salts with bases of fixed alkali is pure, and they are not capable of taking up a redundancy of either principle in their crystals. This however may be doubted.

The crystallization of salts is usually effected by evaporating part of the water; but it may likewise be made to take place by abstraction of the water in the way of chemical affinity. Thus if strong ardent spirit be added to an equal volume of a strong solution of nitre, the spirit combines with the water, and almost the whole of the nitre separates in an instant in the crystalline form. There is no doubt but appearances of this kind of separation have misled chemists on various occasions.

The operation of crystallizing, or crystallization, is of great utility in the purifying of various saline substances. Most salts are suspended in water in greater quantities at more elevated temperatures, and separate more or less by cooling. In this property, and likewise in the quantity of salt capable of being suspended in a given quantity of water, they differ greatly amongst each other. It is therefore practicable in general to separate salts from each other, by due management of the temperature and evaporation. For example, if a solution of nitre and common salt be evaporated over the fire, and a small quantity be now and then taken out for trial, it will be found, at a certain period of the concentration, that a considerable portion of salt will separate by cooling, and that this salt is for the most part pure nitre. When this is seen, the whole fluid may be cooled to separate part of the nitre, after which, evaporation may be proceeded upon as before. This manipulation depends upon the different properties of the two salts with regard to their solubility and crystallization in like circumstances. For nitre is considerably more soluble in hot than in cold water, while common salt is scarcely more soluble in the one case than in the other. The common salt consequently separates in crystals as the evaporation of the heated fluid goes on, and is taken out with a ladle from time to time, whereas the nitre is separated by successive coolings at proper periods.

Those chemists who consider heat as a peculiar substance and not a modification of matter, are in general inclined to reckon the fluid state a solution in this matter; and the crystallization of bodies merely fused, is by them accounted for by the abstraction of this supposed solvent.

It was natural for the earlier mineralogists and chemists to distinguish bodies by their symmetrical figures. Subsequent experience has however shewn that the crystallization of bodies is variable, by so many and such minute circumstances, that a considerable dependance on this single attribute must necessarily be productive of error. Modern chemists, as the methods of analysis became more

perfect, seem to have adopted a prejudice of the contrary nature, by almost totally rejecting the external figures of bodies as indications of their component parts. Romé de Lisle in his *Crytallographie*, Bergman in one of his *Essays*, and the abbé Haüy, have treated expressly and scientifically upon the formation of those geometrical figures which constitute crystals; but the subject is very far from being enough simplified to admit of any ready application. The miner, the mineralogist, and the chemist will perceive a number of circumstances in natural and artificial bodies relative to their configuration, grouping, colour, fracture, specific gravity, &c. by means of which he may form very probable conjectures as to their contents, and the experiments requisite to be instituted upon them: but in the present state of science, there is no method which can be substituted instead of actual inspection, and the attentive consideration of minerals and chemical products whose contents are previously known.

CULM. A term exclusively applied by dealers in pit-coal, to denote such coal as does not cake, or adhere together, when heated. Small pieces of coal of this kind are of much less value than larger pieces; and on this account the duties on culm are less than upon coal. *See COAL.*

CUPEL. A shallow earthen vessel somewhat resembling a cup, from which it derives its name. It is made of phosphorated lime, or the residue of burned bones rammed into a mold, which gives it its figure. This vessel is used in assays wherein the precious metals are fused with lead, which becomes converted into glass, and carries the impure alloy with it. *See ASSAY.*

CUPELLATION. The refining of gold by scorification with lead upon the cupel is called cupellation.

CURD. The coagulum which separates from milk upon the addition of acid or other substances. *See MILK, also CHEESE.*

D.

D A M

D A M

DAMP. The permanently elastic fluids which are extricated in mines, and are destructive to animal life, are called damps by the miners. The chief distinctions made by the miners, are choke-damp, which extinguishes their candles, hovers about the bottom of the mine, and consists for the most part of aerial acid, or fixed air; and fire-damp, which occupies the superior spaces, and does great mischief by exploding whenever it comes in contact with their lights. The history of the effects of these fluids is very curious, and has been given much in detail by various writers. But the general properties of elastic fluids having of late years been much elucidated by the experiments of Dr. Priestley and others, it is at present found as easy to account, in a general way, for the wonderful effects of these fluids, as for any other appearances that take place in chemistry.

DAZE,

DAZE, or GLIMMER. A mine term applied to micaceous substances.

DECANTATION. The action of pouring off the clearer part of a fluid by gently inclining the vessel after the grosser parts have been suffered to subside. Some chemists avoid the use of the filter altogether, and separate solids from fluids by decantation. But there are situations in which either method may be preferable to the other.

DECOCTION. The operation of boiling. This term is likewise used to denote the fluid itself which has been made to take up certain soluble principles by boiling. Thus we say a decoction of the bark, or other parts of vegetables, of flesh, &c.

Decoction is chiefly applied to organised substances, and is rather a culinary or pharmaceutical than a chemical operation. It serves to soften and considerably alter the parts of vegetables and animals; but its effects in general are too gross and complicated to afford satisfactory theoretical results. In this process the volatile parts, if any be present, fly away and are lost; and it is attended with other inconveniences, which the chemical practitioner will very readily perceive.

DECOMPOSITION. This word was formerly used in a sense almost opposite to that which universally prevails at present. Newton, Boyle and other earlier English writers, as the annotator on Macquer's Chemical Dictionary observes, used it to denote the composition or junction of two or more bodies which were previously compounded of other parts. But it is now understood to imply the separation of the component parts or principles of bodies from each other.

It is distinguishable from division, because this last may consist in the separation of parts of the same nature as the body itself, which decomposition does not. Thus common salt may be divided by pulverizing or otherwise, into parts of extreme minuteness, which still continue to be common salt: but it cannot be said to be decomposed, until its alkali and acid are separated from each other.

The decomposition of bodies forms a very large part of chemical science. It seems probable from the operations we are acquainted with, that it seldom takes place but in consequence of some combination or composition having been effected. It would be difficult to point out an instance of the separation of any of the principles of bodies which has been effected, unless in consequence of some combination. The only exceptions seem to consist in those separations which are made by mere heat; and these cannot be admitted as exceptions if we attend to the means by which the temperature was originally raised, or if we admit heat to be a peculiar substance.

DECREPITATION. The small and successive explosions afforded in many chemical operations are distinguished by this name. They are either produced by heating metallic substances with nitre, which take fire and explode, or else by suddenly heating crystallized bodies. Thus common salt which has been deprived of its water of crystallization by heat is called decrepitated. See SALT.

DELFT WARE. A kind of pottery made at Delft in Holland, which formerly supplied all Europe, until it was supplanted by a yellow pottery made in France, which has since given place to the queen's ware, and various kinds of china fabricated in Great Britain.

Pottery may be distinguished into two kinds; namely, that which has a transparent varnish or glaze, and that which has an opaque glaze. The queen's ware, the stone ware, and various kinds of china are of the former sort. The Delft ware and other kinds of china ware are of the latter kind. In every kind of pottery

pottery it is an object of great importance that the expansions and contractions of the glaze and the body should be nearly the same at like temperatures: but this desirable property is seldom found in vessels covered with an opaque glaze or enamel.

As the Delft pottery has fallen into disuse, it seems of less consequence to enquire into its composition, more especially as this disuse has been occasioned by the production of better potteries. The following observations are taken * from a Memoir by Mr. Bosc d'Antic, in the 6th volume of the *Mem. des Savans Etrangers*.

Pure clay is not a fit material, when used alone, for the making of Delft ware. Different kinds of earths mixed together are found to succeed better. Pieces of ware made of clay alone would require too much time to dry; they would crack and would lose their form, unless they were made exceedingly thick. An addition of marle is found to lessen the contraction of the clay, renders it less compact, allows the water to escape in the drying of the ware without alteration of form, and affords a better ground for the enamel, which appears more glossy and white than when laid on clay alone.

The kinds of clay which are chiefly used in the composition of Delft ware, are the blue and green. But a mixture of blue clay and marle would not be sufficiently solid, and would be apt to scale, unless it were exposed to a fire more intense than what is commonly used for the burning of Delft ware. To give a greater solidity some red clay is added, which, on account of its ferruginous matter, possesses the requisite binding quality. The proportions of these ingredients vary in different works, according to the different qualities of the earths employed. Three parts of blue clay, two parts of red clay, and five parts of marle, form the composition used in several manufactories. M. D'Antic thinks that the best Delft might be made of equal parts of pure clay and pure calcareous earth; but this composition would require that the fire should be continued twice as long as it generally is.

The preparation of the white enamel with which this ware is glazed, is another essential part in which many artists fail. M. D'Antic recommends for this purpose a mixture of an hundred pounds of calx of lead, with about a seventh part of that quantity of calx of tin for common Delft, or a fourth part of calx of tin for the finest Delft; an hundred, or an hundred and ten pounds of fine sand; and about twenty or thirty pounds of sea-salt, or salt of glass.

DELIQUESCENT. The spontaneous assumption of the fluid state by certain saline substances, when left exposed to the air, in consequence of the water they attract from thence.

We know of no criterions to determine, *à priori*, whether any combination shall be consistent, efflorescent or deliquescent in the air. It appears that whenever any salt attracts moisture more strongly than the air is disposed to retain it, it is deliquescent; and, on the contrary, if the air be more attractive of moisture, it will cause the salt to effloresce. Salts, which are not commonly deliquescent, will be liquefied in a very humid air, and other salts strongly attractive of humidity may be dried in proper situations.

Generally speaking, the simpler substances are more deliquescent than such as are compounded. So the acids and pure alkalis are all strongly attractive of

* In a note to the English translation of Macquer's Dictionary.

water ; most of the former being disposed to rise in distillation, long before they are deprived of the last portions of water, and consequently they are constantly in the fluid state, unless when congealed by cold.

DELIQUIUM. Deliquescent salts are by some writers said to fall into a deliquium.

DEMI-METAL. A word sometimes used for semi-metal, which see.

DEPHLEGMATION. Any method by which bodies are deprived of water. The term is nearly synonymous with concentration. It is effected either by evaporation or congelation, and is chiefly used in speaking of very aqueous fluids, whereas the word concentration is usually applied to the extreme dephlegmation of acids.

DEPHLOGISTICATED. Deprived of phlogiston, or the inflammable principle. As the existence of this principle is an object of controversy, it would be desirable if all terms referring to it were avoided. The pale nitrous acid is called dephlogisticated nitrous acid : eminently respirable air or vital air is called dephlogisticated air ; the more perfect calces of metals are said to be dephlogisticated, &c. and in all these and other cases it is easy to express the mere facts without using this or any other term dependant upon theory.

DEPHLOGISTICATED AIR. See AIR, VITAL.

DERBYSHIRE SPAR. A combination of calcareous earth with a peculiar acid called the ACID OF FLUOR, which see.

Fluor spar is scarcely harder than the common calcareous spar. It affords no effervescence with acids, though totally soluble in nitrous or marine acid. In an heat below ignition it affords a phosphorescent light, as may be tried by placing a small piece upon an heated poker. Borax easily dissolves it before the blow-pipe, as does also the microcosmic salt without ebullition.

This spar is used as a flux at the mines, whence it has its name. Very elegant ornaments are made of it, which are sold in London at prices which may be termed extravagant, unless there be difficulties in the cutting and polishing of which I am not aware, and suppose there is no reason to imagine.

When the acid of spar shall be applied to more extensive uses than at present, this substance will become of value on that account.

DESTRUCTIVE DISTILLATION. When organised substances or their products are exposed to distillation until the whole has suffered all that the furnace can effect, the process is called destructive distillation. As this method decomposes bodies so as to separate their component parts from each other into a state of considerable simplicity : and as the original principles of organised bodies seem to be few, the products of substances of the vegetable kingdom, though much differing from each other at first, are found to possess characters so similar as to render the method of no great use, unless in conjunction with other processes. The same may be observed of the destructive distillation of animal substances.

DETONATION. A sudden combustion and explosion. The detonations observed in chemical experiments are mostly caused by the destruction of the acid of nitre in contact with some combustible substance. This acid takes fire spontaneously when applied to charcoal or to essential oils (see ACID, NITROUS) : but the sudden explosion called detonation requires that the acid should be in a state nearly or completely dry, and the inflammable substance of considerable fixity.

Various

Various theories of detonation exhibiting considerable ingenuity have been maintained by the earlier chemists, in which the facts are accurately stated and plausibly accounted for. The discoveries of the moderns were however wanting to elucidate this subject. Nitrous salts are decomposable by mere heat, the acid being separated into its component parts, phlogificated and vital air. It is this vital air which so strongly and suddenly destroys combustible substances in the way of detonation. The detonation of common nitre and charcoal is one of the most common, and is seen in the effects of *gunpowder* (which see). In experiments of this kind it is remarkable, that the combustion is maintained by vital air, which is not in the elastic state, but fixed in the nitre: whence it should follow, that either the vital air or the combustible body, even in the fixed state, have a great capacity for heat, of which they contain a large quantity, on the hypothesis of heat being matter. Or if heat be a mere commotion, it will follow that, though the quantity of agitation produced by the sudden coalition of particles, in the act of converting an elastic fluid into a dense body, be such as to produce a great effect in increasing the temperature; yet the quantity is still considerable enough, when vital air and combustible matter unite even in their dense state, to cause the most intense degree of ignition. See CLYSSUS.

The dephlogificated or aerated marine acid, being much more ready to part with its vital air than the nitrous acid, is found to afford a much more sudden and stronger detonation. A new kind of *gunpowder* has accordingly been made out of the salt produced by the combination of this aerated acid and the vegetable alkali, for which recourse may be had to the article *gunpowder*.

The most remarkable detonations in chemistry are afforded by *gunpowder*, *fulminating powder*, *fulminating gold*, *fulminating silver*, certain calces of *mercury*, and the *gunpowder* of dephlogificated marine acid, which see.

DEW. Formerly this name was given to the phlegm that rose first in the distillation of several substances: thus the dew of vitriol, the dew of honey, were the watery liquors, which rise first when these substances are distilled.

DIAMOND. The diamond is a mineral which, on several accounts, appears worthy to compose an order by itself. It is found in a sandy earth in the hither peninsula of India, in the island of Borneo, and in the Brazils. The form of the diamond, when perfect, is that of an eight-sided prism. There are also cubical diamonds, which are suspected to be of a different nature from the others. Diamonds are of a lamellated texture, and may be easily split by a blow in a proper direction. The consent of mankind has fixed an immense value upon this stone. The inimitable qualities to which this preference is attached, are its hardness, which is such that it easily cuts all other substances, and takes a most exquisite and lasting polish; and its very great refracting power, which is so considerable as to occasion all the light to be reflected, which falls on any of its interior surfaces, at a greater angle of incidence than $24\frac{1}{4}$ degrees. Hence its lustre, when cut into the form of a regular solid, is very great. This may be easily understood, when it is considered that an artificial gem does not reflect the light from its hinder surface, until that surface is inclined in an angle of 41 degrees. The diamond therefore will not only throw back all the light which an artificial gem would reflect, but likewise one half as much more; which, falling between the angles of 41 degrees and $24\frac{1}{4}$, would have been suffered to pass through by the false gem. It is not surprising, therefore, that the effect of the diamond

should be so much greater; more especially when we attend to its extreme transparency, and the accuracy of its polish.

No solvent but the vitriolic acid has any effect on this gem; in which if diamond powder be triturated, and evaporation carried on nearly to dryness, the acid grows black, and deposits pellicles that burn, and are entirely consumed. In a heat somewhat greater than is required to melt silver, the diamond is entirely volatilized, and consumed with a slight flame; diminishing common air, and leaving a foot behind.

Diamonds are of all colours: the clear transparent stones are the most esteemed; and, next to them, those of a deeper tinge. Whether these coloured stones be really of the same nature as the clear diamond, has not been ascertained. The lapidaries reckon them to be diamonds from their hardness and lustre.

The value of diamonds is reckoned by weight, at so much the carat. The carat used in this valuation is divided into four parts, called grains; but less than troy grains by one fifth; for one hundred and fifty carats are equal to the troy ounce of four hundred and eighty grains. Rough diamonds, without any flaw or blemish, are valued at two pounds sterling the single carat; and the expence of cutting amounts to $3\frac{1}{4}$ pounds the carat. The value is greatly diminished if the diamond be imperfect, or of a bad figure; and it increases rapidly with the size. To find the worth of a rough diamond, its weight in carats must be squared, and multiplied by two, and the product will be pounds sterling. A cut or finished diamond is worth four times as much as one that is still rough. Those of the greatest brilliancy are sometimes valued at a higher rate; but this value has never been applied to stones of excessive magnitude. It does not appear that any sum exceeding one hundred and fifty thousand pounds has been given for a diamond. See Magellan's improved edition of Cronstedt's Mineralogy, for a considerable mass of entertaining information on this subject.

DIAPHORETIC ANTIMONY. This is a white calx of antimony, made by calcining antimony with thrice its weight of nitre. See **ANTIMONY**.

DIGESTION. The slow action of a solvent upon any substance for a length of time, is called digestion by chemists. In this operation the action of the solvent is frequently assisted by heat, in some instances stronger than in others, but seldom equal to that of boiling water. Chemical writers frequently mention a digesting heat. No definite application is made of these terms, but they usually signify a degree of heat exceeding that of living animals, and less than that of boiling water, such as may be produced by placing a vessel in hot ashes. It may therefore be taken to be somewhere about 150 degrees.

DIGESTIVE SALT. One of the names which have been given to the neutral combination of marine acid and vegetable alkali.

DIGESTOR. The digester is an instrument invented by Mr. Papin about the beginning of the present century, and usually called Papin's digester. It is a strong vessel of copper or iron, with a cover adapted to screw on with pieces of felt or paper interposed. In some vessels of this kind the cover is made of an elliptical form, and is inserted through an opening of the same figure, which it completely closes by application of its upper surface to the internal surface of the vessel. A valve with a small aperture is made in the cover, the stopper of which valve may be more or less loaded either by actual weights, or by pressure from an apparatus on the steel-yard principle.

The

The purpose of this vessel is to prevent the loss of heat by evaporation. The solvent power of water when heated in this vessel is greatly increased, chiefly no doubt on account of its increased temperature, and likewise in all probability on account of the pressure exerted by the re-action of the elastic water or steam which is upon the point of being generated.

I do not hear of many experiments made by this engine. The inventor proposed it as a culinary utensil, by which the gristly and bony parts of animals might be combined with water in the form of a jelly, as is in fact the case. But whether a food so loaded with the phosphoric salt of lime would be wholesome may perhaps admit of serious doubts.

Bergman thought that the digester might exhibit a considerable solvent power of water upon the pure earths, and he considered the deposition of siliceous earth from the hot water of the stupendous fountain of Geyser in Iceland, mentioned by Vontroll, as a proof of such a solution.

DISTILLATION. The separation of a volatile fluid from other substances which are less volatile, by applying a due degree of heat to the mixture, and afterwards condensing the vapours in another part of the apparatus by cooling. The older chemical writers distinguished three kinds of distillation, *per ascensum*, *per descensum*, and *per latus*.

The distillation *per ascensum* is performed with an alembic: here the elastic vapours rise perpendicularly, and are condensed in the head of the vessel, from which they run into the receiver through the beak. Large stills are constructed on this principle. The chief advantage it seems to possess consists in the facility with which the residues of the distillation may be come at; and in those few instances wherein considerable quantities of flowers or pulverulent matter rise along with other vapours which are condensed into the fluid form, it may perhaps afford some facility in separating them.

The distillation formerly denominated *per descensum* consisted in placing certain herbs or other substances in a shallow tray or cullender, which was applied like a cover to a tall cylindrical glass vessel. Another cover was then laid over this cullender, which consisted of a pan containing lighted charcoal. The heat was therefore applied above the materials, and the volatile parts were forced to descend and became condensed against the sides of the vessel. Philosophical chemists at present consider this method as entirely useless; but there are several instances of its convenient and advantageous application in large works, as in the distillation of zinc, of pit-coal, and other substances.

The distillation *per latus* is the simplest and most extensively used: a retort and a receiver are the fewest vessels which can be used in this way; and where the heat is properly managed, every operation of the other methods may be performed in this way with great facility. It has accordingly happened that most of the improvements of distillation for philosophical purposes have been made in this method. See APPARATUS.

The general rule for performing all distillations in the most safe, accurate, and perfect manner consists in applying no more heat than is necessary to raise the volatile matter, and in keeping the receiving apparatus sufficiently cool, either by surrounding it with wet cloths, immersing it in water, occasionally renewed or kept cold by putting ice or snow into it, &c.

DITTANY OF CRETE. Sixteen ounces of the leaves of this plant yield about half a dram of a strong, aromatic, essential oil, which coagulates by cold, resembling

resembling camphor. From an ounce of this plant Neumann obtained with water two drams and a scruple of extract ; and from the same quantity, with spirit of wine, he obtained a dram and a half of resinous extract. He observes that the green colour of the leaves resides in the resin, and is extractible by spirit, especially after water had previously extracted the gummy part, some of which being also soluble by spirit along with the resin, alters the colour of the spirituous tincture.

DIVISION. Some writers use this word as a term to denote every mechanical separation of the parts of bodies. According to this notion, clipping, pounding, trituration, levigation and the like, are methods of division.

DOCIMASTIC ART. This name is given to the art of assaying, or determining by experiments in the small way, the quantities and nature of the component parts of bodies intended to be used in commerce. See ASSAY, BLOW-PIPE, ANALYSIS, and the several metals.

DOME. An hemispherical covering of forged iron, with a tube or chimney proceeding from its upper part. The cavity between the dome and the fuel, and likewise the internal space in the chimney, being filled with air much rarefied by heat produce a strong draft, and greatly increase the intensity of the fire. It has also been supposed to reflect the heat or flame upon the vessels, and on that account a furnace with a cover of this form is called a reverberatory furnace.

DORONICUM. From two ounces of the dry root were obtained by water fourteen drams of extract ; and from the same quantity, with spirit, four drams and a half. This root is supposed by some to be poisonous, especially when fresh.—Neumann.

DRAGON'S BLOOD is a red-coloured, inodorous, and insipid resin, insoluble in water, soluble in spirit of wine and in oils, to both which liquors it communicates a red colour. By fire it is fusible, inflammable, and it emits an acid vapour, like that of benzoin. A solution of dragon's blood in spirit of wine is used for staining marble, to which it gives a red tinge, which penetrates more or less deeply according to the heat of the marble during the application. But as it spreads at the same time that it sinks deep, for fine designs the marble should be cold. Mr. Du Fay says, that, by adding pitch to this solution, the colour may be rendered deeper.

DRAKE or DRUSE-HOL. A Swedish denomination used to express a cluster of crystals which line a cavity in any mineral.

DRYING-OIL. Fat oils require a very long time to become consistent by exposure to the atmosphere; but painters render them more disposed to dry, by boiling them with calces of lead. Linseed oil holding calx of lead in solution, which it takes up by boiling with litharge, is called drying oil from this property.

DUCTILITY. That property or texture of bodies which renders it practicable to draw them out in length, while their thickness is diminished without any actual fracture of their parts. This term is almost exclusively applied to metals, and implies that they are capable of being made into wire, by drawing a portion of the metal through an hole in a plate of steel or other proper composition. The ductility of a metal depends therefore on two circumstances, namely, its malleability or property of extending by pressure, and its tenacity or power of resisting an actual separation of its parts. If the metal be not malleable

enough, it will resist the action of the wire-drawer's plate, and not change its figure to a sufficiently small diameter to come through : if, on the other hand, it be very malleable, but at the same time deficient in tenacity, the part which has been put through the hole may not be strong enough to bear, without breaking, that pull which is necessary to form the wire.

Gold, silver, platina, copper, and iron have tenacity and malleability enough to afford very fine wire. Lead and tin have not tenacity enough to be wrought in this way to any advantage, though the hammer and the laminating rollers are capable of extending them to extreme thinness. Zinc laminates very well, but scarcely supports the sudden action of the hammer without breaking, and is altogether unfit to be drawn into wire.

Most authors confound the words malleability, laminability, and ductility together, and use them in a loose indiscriminate way ; but they are very different. Malleability is the property of a body which enlarges one or two of its three dimensions, by a blow or pressure very suddenly applied. Laminability belongs to bodies extensible in dimension by a gradually applied pressure. And ductility is properly to be attributed to such bodies as can be rendered longer and thinner by drawing them through an hole of less area than the transverse section of the body so drawn.

DUCKSTEIN. The duckstein of the Germans is a white calcareous stone, formed by the deposition of chalk from water, in which it is diffused. It is generally formed on branches or roots of trees, and stones of different kinds, and differs from the stalactites in its mode of formation, this last being deposited by water in the act of evaporation as it transudes through the roofs of caverns.

DULCIFICATION. A medical process consisting in combining the mineral acids with ardent spirit by digestion, or more frequently by distillation. The processes for this purpose are not in general very scientific. When ether is made, the first produce is very pure ardent spirit, little altered, or slightly combined with some acid ; next the ether, then phlogificated or partly decomposed acid, with some vinegar, according to the management of the operation. The dulcified acids of the dispensaries consist of an admixture of these products, which in all probability is seldom the same in different laboratories, where the degrees of heat, the time of charging the receiver, and other essential circumstances, are liable to be varied.

DYING. The art of dying is considered as of great importance to society, according to its present habits and usages. It consists in fixing upon cloths of various kinds any colour which may be required, in such a manner as that they shall not be easily altered by those agents to which the cloth will most probably be exposed during its course of wear.

As there can be no probable cause by which any colouring matter can adhere to any cloth, except an attraction subsisting between the two substances, it must follow that there will be few tingeing matters capable of indelibly or strongly attaching themselves by simple application. For such an attachment would imply that the elective attraction by which it was effected was stronger than all or most others ; a circumstance in the order of events not likely to happen often. On this account it is that most of the dying processes appear to consist in applying some substance or principle to the cloth, which forms a colouring matter, nearly insoluble by combining with some other principle applied to it in its state of adhesion to the cloth.

Dying is therefore a chemical art; and if the operations were no more complicated than is here expressed, it would be easy not only to acquire a perfect theory of its processes, but likewise to bring many of them to perfection, which at present constitute its greatest reproach. But the effects and combinations produced in this way being not only to all appearance dependant on compound actions of chemical affinity, but likewise in general produced by means discovered by mere and almost casual trial, it is found that no small degree of sagacity and assiduous research are necessary to determine the uses and advantages of the several ingredients. In addition to these impediments, the theory of dying has been greatly impeded in its progress, by the little interest men of science have found in attempting to repeat its manipulations, and the jealousy of manufacturers, who, with some justice, are inclined to estimate their property in their own gainful discoveries, as a possession which they have a right to monopolize by keeping them secret. It has accordingly happened from these causes, that dying has been merely a practical art, till very lately, that it has been cultivated by a few eminent chemists.

The earlier theories of dying, like the commencements of the other branches of natural philosophy, have been deduced in objects apparently too remote for our present means of investigation, namely, the configuration of the particles of bodies. Newton, from observations on the colours exhibited by light reflected from, or transmitted through, thin transparent bodies, as exhibited in experiments too few and imperfect to have afforded satisfactory conclusions in the hands of a philosopher of less sagacity, formed a general inference, that the colours of all bodies are governed by the magnitude of their particles. He likewise brought their densities into consideration, as a modifying circumstance, but this only in a conjectural way, and he altogether overlooked that property which on another occasion he had noticed as increasing their refracting power, namely their combustibility. M. Delaval, in his Treatise on Light and Colours, and a subsequent paper in the Manchester Memoirs, has displayed this doctrine very much at large, with many valuable improvements and discoveries. It is evident however that much remains to be done before any clear and practical application of this theory can take place. If we suppose that a due magnitude and refractive power be all that is necessary for the particles of bodies to exhibit a determinate colour in white light, which indeed seems to be nearly proved, we shall find no data among our present acquisitions sufficient to afford any determination of these requisites. To produce a green colour there will be no constant thickness or magnitude of particles required; for this will vary with the reflective power. We know that the reflective and refractive powers are the same, and are not governed by the mere density, but are greatest in combustible bodies. And when, in addition to these difficulties with grosser bodies, we observe that there is no possibility of determining either the magnitude, figure, density, or other obvious properties of indiscernible particles, we may justly conclude that it will be a long time before we shall be able to apply the Newtonian theory to the art of dying.

The theory of the celebrated Hellot, supposed that the pores of bodies are opened by the heat used in dying, that the colouring matter was deposited in these interstices, and there firmly held by the subsequent contraction of cooling, assisted by a kind of varnish or covering deposited by the salts made use of. This theory has not met with much success, though, like other hypothetical speculations

(speculations on obscure objects, it may not be difficult to apply it to most of the known facts. It is moreover contradicted not only by the circumstance that the stuff does not in all instances take the colour of the dyer's bath, but some other colour, and that it sometimes happens that the bath, instead of sharing its colour with the stuff, as it ought to do, is rendered as clear as water by an entire privation of all its tinging matter: both which circumstances evidently prove that a chemical combination takes place in consequence of an attraction exerted between the stuff and the colouring matter.

The attention of philosophers is not therefore at present much directed towards the mechanism of the particles of bodies used in dying, but to the elective attractions exercised between them, and the nature of the compounds they form. In this enquiry they have naturally endeavoured to extend their researches by endeavouring to generalize particular facts. Some have supposed the various colours of bodies to be in a very great measure owing to the presence of iron; a body the most universally diffused, and susceptible of a great variety of shades of colour, according to the degree of calcination it may have undergone. It does not however appear that this metal, though so widely diffused, is found in sufficient quantity to be admitted as the efficient cause of the tinges induced upon bodies. But the more modern chemists have with no small degree of probability applied the doctrines of combustion and revivification, or the combination and disengagement of vital air to the fixation and discharging of colours.

The most remarkable general fact in the art of dying consists in the different degrees of facility with which animal and vegetable substances attract and retain colouring matter, or rather the degree of facility with which the dyer finds he can tinge them with any intended colour. The chief materials of stuffs to be dyed are wool, silk, cotton and linen, of which the former are more easily dyed than the latter. This has been usually attributed to their greater attraction to the tinging matter; though it does not appear to be true in all cases, because the stuffs more difficult to be dyed will absorb a greater quantity of that matter, before they acquire the requisite intensity of colour obtainable in the former by a less proportion of the same drug. In every attempt to deduce the causes of these different effects, it is proper to enquire into the properties of these bodies by experiment.

Wool, silk, cotton, and linen, though in various respects similar to each other, are nevertheless found to differ exceedingly in others. In the method of* destructive distillation, wool yields much impure volatile alkali, a portion of empyreumatic oil, leaving about one fifth of incombustible fixed residue. Silk affords less volatile alkali and oil, and more residue. Cotton affords no volatile alkali and little oil, but some acid, leaving little coal which may for the most part be burned by calcination in the air. Here we observe a very considerable difference in the habitudes and products of the several substances; but the scientific experiments of Berthollet shew it still more evidently. He distilled nitrous acid from silk†, and obtained saccharine acid, with a greasy matter, which, though it at first congealed on the surface of the liquor in the receiver, was afterwards dissolved in it by means of heat, even though diluted with water with which it passed through the filter. Wool also afforded the same greasy matter, and acid of sugar; the last of which was more abundant in quantity than he obtained by the same

* Neumann.

† Journal de Phys. xxix.

treatment from any other substance. But the oily part of vegetables was totally destroyed by similar treatment, no greasy matter being afforded; and on analysing cotton, he obtained saccharine acid, but no other product, and the quantity was far inferior to that yielded by animal substances. It was remarkable that the cotton left no residue, but was entirely converted into elastic fluid and saccharine acid, which last is likewise easily convertible into the permanently elastic acid, called fixed air.

Mr. Henry, * in his remarks on these experiments, appears to think that the chief difference between the animal and vegetable substances consists in the former containing a more abundant greasy principle, soluble in a watery menstruum, which the more sparing portion of oil in the latter is not; and likewise in the animal substance containing alkali, or at least one of its component parts: whereas the vegetable affords acid. On these circumstances indeed the different modes of treatment evidently depend. So that it is remarkable that vegetable substances, whose oil is wholly destroyed by nitrous acid, and to whose texture the mineral acids are in general injurious, will bear steeping in solutions of caustic alkali of such strength as would prove totally destructive to wool.

Wool is naturally so much disposed to combine with colouring matter that it requires but little preparation for the immediate processes of dyeing; nothing more being required than to cleanse it, by scouring from a fatty substance, called the yolk, which is contained in the fleece. For this purpose an alkaline liquor is necessary; but as alkalis injure the texture of the wool, a very weak solution must be used. For if more alkali were present than is sufficient to convert the yolk into soap, it would attack the wool itself. Putrid urine is therefore generally used, as being cheap and containing a volatile alkali, which uniting with the grease, renders it soluble in water.

Silk when taken from the cone is covered with a kind of varnish, which, because it does not easily yield either to water or ardent spirit, is usually said to be soluble in neither. It is therefore usual to boil the silk with an alkali, to disengage this matter. Much care is necessary in this operation, because the silk itself is easily corroded or discoloured. Fine soap is commonly used, but even this is said to be detrimental; and the white China silk, which is supposed to be prepared without soap, has a lustre superior to that of Europe. It is however more than probable that the Chinese have a different kind of silk-worm besides that cultivated in Europe. A weak solution of mild mineral alkali has been used with success by M. Rigaut, in clearing silk of its varnish, and the Abbé Cullomb has performed the same thing by boiling silk for nine hours in water. Silk loses about one fourth of its weight by being deprived of its varnish.

The whiteness and softness of silk is considerably improved by clearing it of its varnish; but it receives a still farther degree of brilliancy by exposing to the fumes of sulphur, sublimed or set on fire in a close stove or closet. What happens in this operation has not been well explained. Silk thus treated has a crisp feel, as if flowers of sulphur were inclosed between its threads, which is probably the case. It seems as if a portion of the sulphur entered into combination with the colouring principle of the silk, and formed a colourless or transparent compound: and accordingly it is found less capable, in general, of being easily dyed than the silk which has not been scoured and sulphured.

* Manchester Memoirs III.

Cotton and linen are cleared of a tinging matter, which Mr. Kirwan finds in the latter to be neither gummy nor resinous, but rather resembling lac. Alkalis act upon this matter, and dissolve it after it has suffered a kind of combustion by exposure to air and the sun's light in the bleach ground. See BLEACHING.

The intention of the previous preparations seems to be of two kinds. The first to render the stuff or material to be dyed as clear as possible, in order that the aqueous fluid to be afterwards applied, may be imbibed and its contents adhere to the minute internal surfaces. The second is, that the stuff may be rendered whiter and more capable of reflecting the light and consequently enabling the colouring matter to exhibit more brilliant tints.

Some of the preparations however, though considered merely as preparative, do really constitute part of the dying processes themselves. In many instances a material is applied to the stuff to which it adheres, and when another suitable material is applied, the result is some colour desired. Thus we might dye a piece of cotton black, by immersing it in ink; but the colour would be neither good nor durable, because the particles of precipitated matter formed of the calx of iron, and acid of galls, are already coagulated in masses too gross either to enter the cotton, or to adhere to it with any considerable degree of strength. But if the cotton be soaked in an infusion of galls, then dried, and afterwards immersed in a solution of vitriol (or other more proper ferruginous salt), the acid of galls being every where diffused through the body of the cotton, will receive the particles of calx of iron, at the very instant of their transition from the fluid or dissolved to the precipitated or solid state; by which means a perfect covering of the black inky matter will be applied in close contact with the surface of the most minute fibres of the cotton. This dye will therefore not only be more intense, but likewise more adherent and durable.

The French dyers, and after them the English, have given the name of the mordant to those substances which are previously applied to piece goods, in order that they may afterwards take a required tinge or dye.

It is evident that if the mordant be universally applied over the whole of a piece of goods, and this be afterwards immersed in the dye, it will receive a tinge over all its surface; but if it be applied only in parts, the dye will strike in those parts only. The former process constitutes the art of dying, properly so called; and the latter, the act of painting, staining, or printing, woollens, cottons, or linens.

In the art of printing piece goods, the mordant is usually mixed with gum seneca and applied by means of blocks or wooden engravings in relief, or from copper plates, and the colours are brought out by immersion in vessels filled with suitable compositions. Dyers call the latter fluid the bath. The art of printing affords many processes in which the effect of mordants, both simple and compound, are exhibited. The following is taken from Berthollet.

The mordant employed for linens, intended to receive different shades of red, is prepared by dissolving in eight pounds of hot water, three pounds of alum, and one pound of sugar of lead, to which two ounces of potash and afterwards two ounces of powdered chalk, are added.

In this mixture the vitriolic acid combines with the lead of the sugar of lead, and falls down because insoluble, while the argillaceous earth of the alum unites with the acetous acid disengaged from the sugar of lead. The mordant therefore consists of an argillaceous acetous salt, and the small quantities of alkali and chalk

chalk serve to neutrallize any disengaged acid which might be contained in the liquid.

Several advantages are obtained by thus changing the acid of the alum. First, the argillaceous earth is more easily disengaged from the acetous acid, in the subsequent processes, than it would have been from the vitriolic. Secondly, this weak acid does less harm when it comes to be disengaged by depriving it of its earth. And thirdly, the acetous alum not being crystallizable like the vitriolic alum, does not separate or curdle by drying on the face of the blocks, for printing, when it is mixed with gum or starch.

When the design has been impressed by transferring the mordant from the face of the wooden blocks to the cloth, it is then put into a bath of madder, with proper attention that the whole shall be equally exposed to this fluid. Here the piece becomes of a red colour, but deeper in those places where the mordant was applied. For some of the argillaceous earth had before quitted the acetous acid, to combine with the cloth; and this serves as an intermedium to fix the colouring matter of the madder in the same manner as the acid of galls, in the former instance, fixed the particles of calx of iron. With the piece in this state, the callico-printer has only therefore to avail himself of the difference between a fixed and a fugitive colour. He therefore boils the piece with bran, and spreads it on the grals. The fecula of the bran takes up part of the colour, and the action of the sun and air renders more of it combinable with the same substance. The operations of boiling with bran and exposure in the field are alternately repeated till the ground becomes white and the design only remains. It seems evident that this discharge of the colour is performed nearly in the same way as bleaching, the bran being substituted instead of the alkali, because this last would act upon the printed colour and partly discharge it.

In the foregoing instance the mordant was completely formed by the effect of the double elective attraction of the principles of the sugar of lead and of the alum. In other cases however the elective attraction of the stuff to be dyed has a more marked agency. A very common mordant for woollens is made by dissolving alum and tartar together; neither of which is decomposed, but may be recovered by crystallization upon evaporating the liquor. Wool is found to be capable of decomposing a solution of alum, and combining with its earth: but it seems as if the presence of disengaged vitriolic acid served to injure the wool, which is rendered harsh by this method of treatment, though cottons and linens are not, which have less attraction for the earth. Wool also decomposes the alum, in a mixture of alum and tartar: but in this case there can be no disengagement of vitriolic acid, but it is immediately neutralized by the alkali of the tartar.

Alum is an exceedingly useful agent in dying processes, and M. Berthollet has satisfactorily proved, by a variety of experiments, that its earth has a strong tendency to unite with animal matters, and that its attraction for vegetable substances is very weak, excepting to their colouring parts.

Metallic calces have so great an attraction for many colouring substances, that they quit the acids in which they were dissolved, and are precipitated in combination with them. These calces are also found by experiment to be strongly disposed to combine with animal substances; whence in many instances they serve as mordants, or the medium of union between the colouring particles and animal

animal bodies. But it has not been shewn that any considerable attraction is exerted between these calces and vegetable substances.

A considerable progress has been made of late years in the investigation of such facts as tend to afford a theory of the art of dying. The following general abstract of this theory is taken from Berthollet.

Metallic colours must be distinguished from those which are peculiar to vegetable and animal substances.

The colours of metals are modified and changed by calcination, according to the degree to which it is carried.

Vegetable and animal substances may themselves possess a peculiar colour, which varies in the different states through which they pass; or they may owe their colours to tingeing particles, either combined or simply mixed with them. These are the particles which are extracted from different substances, and which undergo different preparations, to fit them for the purposes of dying.

The colouring particles have chemical properties which distinguish them from all other substances: the attractions which they have for acids, alkalis, earths, metallic calces, vital air, wool, silk, cotton, and linen, constitute the chief of these properties.

According to the attraction which the colouring particles have for wool, silk, cotton and linen, they unite more or less readily, and more or less intimately with each of these substances; and thence arises the first cause of variation in the processes employed, according to the nature of the stuff and of the colouring substance.

By the attraction which the colouring particles have for argillaceous earth and metallic calces, they form compounds with these substances, in which their colour is more or less modified, becomes more fixed, and more difficultly affected by external agents, than before. This compound being formed of principles, which have separately the power of uniting with vegetable substances, and more especially with animal substances, preserves this property, and forms a triple compound with the stuff; and the colour which has been again modified by the formation of this triple union, acquires a greater degree of fixity, and of indestructibility by external agents.

The colouring particles have frequently so great an attraction for clay and metallic calces, that they separate them from acids which held them in solution, and fall down with them; but the attraction of the stuff is sometimes necessary, in order to produce this separation.

The metallic calces which combine with the colouring particles, modify their colours, not only by their own, but also by acting upon their composition by means of their vital air. The change which the colouring particles thereby suffer, is similar to that occasioned by the air, which injures all colours more or less.

Of the two principles which compose the air of the atmosphere, it is only the vital air, or oxygenous gas, which acts upon the colouring particles: it combines with them, weakens their colour, and renders it paler; but its action is principally exerted on the hydrogen, or inflammable air, which enters into their composition, and it then forms water. This effect ought to be considered as a true combustion, whereby the charcoal which enters into the composition of the colouring particles becomes predominant, and the colour commonly changes

to yellow, fawn colour, or brown; or the injured part, by uniting with what remains of the original colour, produces other appearances.

Light favours the combination of the colouring particles, which frequently cannot take place without its aid; and it is thus that it contributes to the destruction of colours. Heat promotes it also, but less powerfully than light, unless it has a certain degree of intensity.

To a similar combustion are to be attributed the effects of the pale nitrous acid, of the oxygenated or aerated muriatic acid, and even of the sulphuric acid, when they make the colour of the substances upon which they act pass to a yellow, and even to a black.

The effects of combustion may however be concealed by the vital air combining with the colouring particles, without acting particularly on the inflammable air.

Colours are more or less durable, or more or less fixed, according to the greater or less disposition of the colouring particles to undergo combustion, and to allow it to go on to a more or less advanced stage.

Some substances are also capable of acting on the colour of stuffs by a superiority of attraction, or by a solvent power; and in this consists the action of acids, alkalis, and soap. A small quantity of these agents, however, may sometimes form supracompounds with the stuff, and thereby change its colour.

Metallic calces produce, in the colouring particles with which they unite, a degree of combustion proportioned to the quantity of vital air which can be taken from them by these particles.

The colours which the compounds of metallic calces and colouring particles assume, then, are the product of the colour peculiar to the colouring particles, and of that peculiar to the metallic calx; but the colouring particles and metallic calces must be considered in that state to which they have been reduced by the diminution of vital air in the calx, and the diminution of hydrogen in the colouring particles.

Hence it follows: First, that the metallic calces to which the vital air is only slightly attached, are not fit to serve as connecting mediums for the colouring particles, because they produce in them too great a degree of combustion; such are the calces of silver, gold, and mercury.

2d. That the calces which undergo considerable changes of colour, by giving off more or less of their vital air, are also bad intermediaries, especially for light shades, because they produce changeable colours; such are the calces of copper, of lead, and of bismuth.

3d. That the calces which strongly retain their vital air, and suffer very little change of colour by the loss of a part of it, are best fitted to answer this purpose: such is particularly the calx of tin, which quits its menstruum easily, which has a strong attraction for the colouring particles, and which affords them a basis which is very white, and proper for giving a brightness to their shades, without altering them by the admixture of another colour. The calx of zinc possesses some of these qualities.

In order to account for the colours which result from the union of the colouring particles with the basis which a mordant gives them, we must attend to the proportion in which the colouring particles unite to that basis: thus the solution of tin, which produces a very copious precipitate with a solution of colouring particles, and thereby proves that the calx of tin enters in a large

proportion into the precipitate, has a much greater influence on the colour of the precipitate, by the whiteness of its basis, than the solution of zinc or that of alum, which generally produce much less copious precipitates. The precipitates produced by these two last substances retain very nearly the natural tint of the colouring particles.

We must then distinguish, in the action of mordants, the combinations that may take place by their means between the colouring particles, the stuff, and the intermedium; the proportions of the colouring substance and intermedium; the modifications of colour, which may arise from the mixture of the colour of the colouring particles, and of that of the basis to which they are united; and finally, the changes which the colouring particles may suffer from the combustion that may be produced by the intermedium.

Astringents do not derive their characteristic property from an acid, or from any other individual principle which is always the same, but from the property which they possess of uniting with the calx of iron, of reducing it to the state of black calx, and of acquiring themselves a dark colour, by the combustion they experience. Galls, which are to be considered as the representatives of all astringents, readily undergo a slight combustion, which gives them a deep brown colour; but this combustion, which requires but a small quantity of vital air, soon ceases without injuring their properties.

Galls owe their stability to the large proportion of charcoal they contain; and as they have the property of combining with some vegetable substances, with several colouring matters, and particularly with animal substances, they serve as intermedium for them, and impart to them their own firmness of colour.

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E A R T H. Chemists sometimes in a gross and inaccurate way call those substances earths which remain after the volatile products of distillation have arisen, and which are not soluble in water. This is not however sufficiently exact, though it is difficult to exhibit a good positive definition. Earths are bodies simple with respect to the present powers of chemical analysis, brittle, incombustible, infusible by the heat of furnaces, not soluble in many hundred times their weight of water, and destitute of that opaque brilliancy which characterises metals. There are few earthy substances which may not be reduced by analysis to one of the five following primitive earths:—the siliceous, argillaceous, calcareous, ponderous, and magnesian earths; or otherwise, taken substantively, they are called flint, clay, lime, barytes, and magnesia.

The adamantine spar, the jargon of Ceylon, and a mineral substance from New South Wales, have afforded earthy substances which, as far as experiments have

have yet determined, are different from any of these five. But they will not materially affect the general arrangement of chemistry, until future researches shall have proved that they are more abundantly found than at present we have reason to suspect.

The attention of the chemical world has been strongly excited by some experiments of Messrs. Ruprecht and Tondi, who affirmed that they had reduced the argillaceous, calcareous, ponderous, and magnesian earths to the metallic state by strongly heating them with charcoal. But however probable it may be from analogy that such reductions may be within the limits of possibility, it is now universally admitted, that the metal obtained in these experiments consisted of iron from the crucibles made use of.

In some systems a distinction is made between earths and stones; but this is of no utility in the enquiry respecting their component parts and properties. A stone is nothing more than a hard earthy mass, and an earth in powder is an aggregate of very minute stones.

EARTH, ADAMANTINE. A peculiar earth, composing about one third part of the weight of the adamantine spar. By repeated fusions of this spar with fixed alkali, and separation of the known earths by subsequent treatment with distilled water and with acids, Mr. Klaproth obtained this earthy substance, distinguishable from the soluble earths in not yielding to the action of acids, and from siliceous earth in resisting alkalis. A further investigation of its properties is wanting, but will not perhaps be easily obtained, on account of the small attractive power which the usual chemical solvents have upon it. *See ADAMANTINE SPAR.*

EARTH, ANIMAL. The fixed and insoluble residues of animal substances have been distinguished by this name, more especially before their component parts had been ascertained by late analysis. They consist of calcareous earth in combination with some acid. The bony coverings of shell-fish contain a large portion of mild calcareous earth, united with aerial acid or fixed air. The shells of eggs, of snails, and probably all the hard brittle external coverings of animals, are said to be of the same nature. The basis of bones, as well in sea as in land animals, consists of calcareous earth saturated with phosphoric acid. *See ACID PHOSPHORIC.* I do not know of any experiments tending to ascertain the presence of any other earth, as a necessary component part of animal bodies, but the calcareous.

EARTH, ARGILLACEOUS. The principal natural specimens of argillaceous earth are clays, properly so called, marles, boles, slates or schistus, and mica. In none of these, except the flag stone, does the argillaceous earth amount to so much as half their weight, though their predominating qualities appear to depend upon it. The most obvious characters of this earth are, an adhesion to the tongue, or any wet and soft body, in the more solid specimens; and a remarkable tenacity, ductility, or kneadability serve to distinguish moistened clays in a most eminent degree. It is soluble in acids; but alkalis act much less upon it, either in the dry or moist way, than they do on siliceous earth. Alum is a combination of argillaceous earth with vitriolic acid. If the concrete volatile alkali be added to a solution of pure alum, the alkali and acid unite, while the clay falls to the bottom, united only with a small quantity of fixed air. The fluid must be abstracted by decantation, and the precipitate washed with distilled water, and dried.

Clays may be easily diffused and suspended in water, but are not soluble in any sensible degree. The sudden application of strong heat hardens their external parts, which afterwards burst by the explosion of the moisture within. By a more gradual heat pure clay contracts very much, becomes hard, and full of cracks or fissures. The presence of siliceous earth in common clays, where it usually constitutes above half the weight, renders the contraction more uniform throughout, and prevents the cracks; probably in no other way than by rendering them more numerous, and too small to be perceived. When thus baked, it constitutes all the varieties of bricks, pottery, and porcelain. These, if baked in a strong heat, give fire with steel; a property that may be attributed to the siliceous earth they contain, which cannot act on the steel unless firmly set in the hardened clay. The dimensions of pottery are less, the greater the heat to which the article has been subjected. On this property is constructed a thermometer for measuring the heat of furnaces, by igniting a small brick of known dimensions therein, and afterwards measuring its contraction. Baked clay is no longer kneadable with water, though as finely pulverized as mechanical means can go. Hence it has been inferred, that clays owe their ductility to a kind of gluten, which is supposed to be dissipated by heat. They recover that property, however, by solution in an acid and precipitation; whence it should seem to depend either on a minute portion of acid contained in clays, or the smallness of the particles when precipitated.

For the habitudes of clay with acids, see the several acids.—*See also* BRICKS, POTTERY, THERMOMETER WEDGWOODS.

EARTH, CALCAREOUS. Calcareous earth, or lime, predominates in most stones which are soft enough to be scratched with a knife. These are chalk, limestone, marble, spars, gypsum, or plaster-stone, and various others. As the lime is most frequently combined with fixed air, it is usual for mineralists to drop a small quantity of nitrous acid upon the stones they are desirous of classing; and if it froths by the escape of the fixed air, they conclude that lime enters into the composition. To obtain pure calcareous earth, powdered chalk must be repeatedly boiled in water, which will deprive it of the saline impurities it frequently contains. It must then be dissolved in distilled vinegar, and precipitated by the addition of concrete volatile alkali. The precipitate, when well washed and dried, will consist of lime united to fixed air; the latter of which may be driven off by heat, if necessary.

If chalk, marble, limestone, spar, or any other specimens of this earth, containing fixed air, be exposed to continued ignition, they give out fixed air and water, to the amount of near half their weight. The remainder, consisting chiefly of lime, has a strong tendency to combination, and attracts water very powerfully. The addition of water to lime produces a very considerable heat, attended with noise, and agitation of the parts, which break asunder; and a phosphoric light is seen, if the experiment be made in the dark. Lime thus saturated with water is said to be slaked. Water dissolves about one seven-hundredth part of its weight of lime, and is then called lime-water. This solution has an acid taste, and turns syrup of violets to a green colour. If lime-water be exposed to the open air, the lime attracts fixed air, and is by that means converted into chalk; which, not being soluble in water, forms a crust on the surface, formerly called cream of lime, that, when of a certain thickness, breaks, and falls to the bottom: and in this way the whole of the lime will in
time

time be separated. If the fire has been too violent in the burning of lime, the stone becomes hard, sonorous, and incapable of absorbing water with the requisite degree of avidity. This effect seems to arise from part of the calcareous earth having entered into fusion with the clay, flint, or other contaminating earths, with which it forms a glass that covers and defends the rest.

The paste of lime and water, called mortar, has a degree of adhesion and ductility, though much less than clay. When dry, it is more or less friable, like chalk. A mixture of sand, or broken earthen vessels, greatly increases its firmness, which it seems to effect by rendering it more difficult for the parts to be removed with respect to each other. When mortar is left to dry by the gradual evaporation of its superfluous water, it is very long before it obtains its utmost degree of firmness. But if dry quick-lime be mixed with mortar, it gradually absorbs the superfluous water, and the mass becomes solid in a very short time.

Gypsum, or plaster of Paris, consists of lime united to the vitriolic acid, together with water. If this substance be exposed to a moderate heat, part of the water is driven off with an appearance resembling ebullition. The dry powder which remains may be mixed with water to the consistence of thin paste, and poured into a mould; and soon afterwards it suddenly becomes solid; at the same time that it is a little heated, and its bulk somewhat increased. This effect may be explained by observing that the particles of the gypsum are at first simply wetted by the water, in the same manner as happens with clay; and for that reason no other effect takes place, than the production of an imperfect degree of fluidity, from the motion of the parts among each other being facilitated: but when the water, by the gradual progress of the action between it and the dried gypsum, becomes combined in the same manner as before the calcination, it is absorbed, and enters into the composition of a solid body; the imperfect fluidity arising from the presence of uncombined water disappears, heat is developed, and the whole mass takes the solid form.

If the heat be strong, or continued any considerable time after the appearance of ebullition has ceased, the selenite will be partly decomposed by the loss of some of its vitriolic acid, and the plaster will be unfit for this purpose. The use of plaster in casting small statues, medallions, and other ornaments, is well known.

From various pertinent observations, Chaptal has shewn that gypsum is formed by the gradual decomposition of pyrites, which form vitriolic acid. This being carried off by water, takes up lime in its course, and the combination is afterwards deposited in consequence of the spontaneous evaporation of the water.

Calcareous earth, though infusible in the strongest heats of our furnaces, is nevertheless a very powerful flux with regard to mixtures of the other earths. These are all fusible by a proper addition of calcareous earth. Compounds are still more fusible; for any three of the five well-known earths may be fused into perfect glass, if they be mixed together in equal portions, provided the calcareous be one of them.

The earthy part of animals is chiefly, if not altogether, calcareous: in most cases it is united with phosphoric acid, but frequently with fixed air. See EARTH, ANIMAL.

EARTH, FULLERS. Among the useful researches, for which we are indebted

debted to the illustrious Bergman, we find one upon Lithomarga*, or stone marle; which seems to differ from common marle in its composition, chiefly in possessing a much larger portion of siliceous, and less of calcareous earth. Fullers earth is one of the most useful varieties of Lithomarge.

Cronstedt describes † Lithomarge under the following general characters: First, When dry, it is smooth and slippery like hard soap. Secondly, It is not perfectly diffusible in water; but when immersed in that fluid it falls into pieces of greater or less magnitude, or in such a manner as to assume the appearance of curds. Thirdly, In the fire it easily melts into a white or reddish frothy slag, which is considerably larger than before, in consequence of its porosity. Fourthly, Its fracture is irregularly convex or concave.

This author describes only the Lithomargæ of Osmund, of Tartary, and of Lemnos; the Hampshire fullers earth not having come to his hands, probably on account of the severe penalties imposed by the English legislature on its exportation. Bergman examined them all, except the second, which is the Keffekil of the Crim Tartars, who are said to use it instead of soap, and of which he was not provided with a sample. Wiegleb, in Croll's Journal, quoted by Kirwan ‡, found that it consists of equal parts magnesia and siliceous earth.

The Lemnian earth, highly esteemed for many centuries for its supposed medical virtues, and till lately sold in Europe under the seal of the Grand Signor, has the external appearance of clay with a smooth surface, resembling agate, especially in its recent fractures, which are usually either concave or convex. It may be scraped with the nail, is composed of impalpable particles, though a little gritty between the teeth, under which it feels like tallow. When immersed in water, it is spontaneously divided into small pieces with a slight crackling noise, but they do not become so small as to be invisible or impalpable. Pulverization and boiling in water diffuses it in the fluid, which passes almost perfectly clear through doubled filtering paper. The water examined by the usual tests is found to be neither acid nor alkaline, but exhibits the presence of marine acid in combination.

This earth removes impurities like soap, though it affords no froth. When urged by the blow-pipe, it does not decrepitate, but turns black, melts with ebullition, and becomes converted into a dark frothy slag. With microcosmic salt there is a commencement of solution with effervescence; but the remainder is scarcely affected. Borax acts more effectually, though slowly, on the residuum. Mineral alkali occasions a considerable effervescence with noise. By the humid analysis, Bergman found it to contain forty-seven parts in the hundred siliceous earth, $5\frac{1}{2}$ of mild calcareous earth, $6\frac{1}{8}$ of mild magnesia, 10 of argillaceous earth, $5\frac{1}{2}$ calx of iron, and 17 of moist volatile matter expellable by drying.

The Osmundic earth comes from mount Osmund, in the parish of Ratwick in East Dalecarlia. Its colour is grey, like cinders, its surface rough, and as if greased. It is harder than the Lemnian earth, breaks into angular pieces, adheres strongly to the lip, and is more gritty between the teeth than that earth. In water it separates into smaller particles, and is detergent.

This earth decrepitates before the blow-pipe, turns black, and melts with ebullition, leaving a white frothy slag. It exhibits the same phenomena as the Lem-

* In the third vol. of his Essays, Eng. translation.

† Magellan's Eng. ed. i. 234.

‡ Mineralogy, p. 60.

nian earth with the blow-pipe; but a grain of it thrown into the solution becomes white. It effervesces less with the mineral alkali.

From the humid analysis, Bergman found one hundred parts of the Osmundic earth to contain 60 parts white siliceous powder, $5\frac{7}{8}$ calcareous earth, $0\frac{7}{8}$ magnesia, $11\frac{1}{8}$ argillaceous earth, $4\frac{7}{8}$ calx of iron, and 18 of moist volatile matter.

The Hampshire fullers earth, examined by Bergman, was of a dark colour, a little inclined to green, and faintly marked with yellowish veins, less hard than the Osmundic and Lemnian earths, capable of being polished with the nail, of a rough fracture with dark pointed eminencies, adhering to the lip, and a little siliceous between the teeth. When immersed in water, it fell to pieces like the other earths. It produced no froth when rubbed with water, but was exceedingly detergent.

Water in which pulverized fullers earth was boiled, passed still turbid through several folds of paper, and the water indicated the presence of combined marine acid. Before the blow-pipe it decrepitated, but less than the Osmundic earth; after which it turned black, was fused with ebullition into a dark-coloured spongy mass. Its habitudes with borax, microcosmic salt, and mineral alkali, were the same as those of the Lemnian earth.

Bergman's method of analysing this and the two preceding earths was the following: An hundred parts or docimastic pounds of the earth were pulverized, and inserted into a small glass cucurbit with twice its weight of highly concentrated vitriolic acid; after which a capital and receiver being adapted, the distillation was performed on a sand bath. An acid vapour arose by the first gentle heat, which was found to be marine acid; doubtless, says Bergman, arising from decomposed sea-salt. A greater heat did not exhibit any signs of volatile alkali. He then decanted off the superfluous acid, washed the residuum in distilled water, dried it, and found its weight. This was found to be siliceous earth contaminated with iron.

The next object consisted in ascertaining the contents of the acid which had been decanted off. For this purpose he divided it into two parts. To one part, made very warm, he gradually added finely pulverized chalk, taking great care not to exceed the due quantity. The chalk precipitated whatever clay or iron might be present; but left the magnesia in solution, because the sum of the quiescent attractions of lime to fixed air, and vitriolic acid to magnesia, are greater than the divellent attractions of the fixed air to magnesia, and vitriolic acid to lime; so that the presence of the fixed air prevented that decomposition of vitriolated magnesia which would have taken place if mere lime had been used.

After the precipitation of clay and iron from the solution he evaporated the liquor, which occasioned the separation of vitriolated lime or selenite, and vitriolated magnesia, or Epsom salt; the latter of which, on account of its much greater solubility, was taken up by a little warm water. Another evaporation and solution of the Epsom salt was made, to clear it entirely of the selenite. Mild fixed alkali was used to precipitate the earths from the respective solutions of these two salts, and the remaining liquors were subjected to ebullition for a quarter of an hour, to throw down the small portion of earth which might be suspended by the redundant fixed air. In this way, consequently, the true quantities by weight of magnesia and of lime, contained in half the centenary, were ascertained, taking care to deduct the weight of chalk made use of in the precipitation.

In

In the foregoing process the iron and clay were precipitated, that they might be no impediment to an examination of the quantities of lime and magnesia. The separation of the clay from the iron not being a very direct operation, the other half of the original solution was reserved for the purpose of determining their weights. Prussian alkali was therefore added to this half of the solution; in consequence of which the iron fell down in the form of Prussian blue, leaving the earths suspended. The quantity of iron was determined by allowing ten grains of iron for each fifty-nine grains of blue precipitate.

In the next place the solution was filtered, now containing clay, magnesia, and lime, all combined with vitriolic acid; out of which the quantity of the first only was required to be found. The solution was therefore concentrated by evaporation, and the excess of acid then saturated, by the addition of mild magnesia, till paper stained with turnsole was not affected by it. An excess of magnesia was guarded against, by suffering each small portion to be entirely dissolved before any more was added. After half an hour's boiling, the neutral combination of clay and vitriolic acid fell down, it being well known that the solubility and other properties of alum depend on its excess of acid: and this combination being digested with mild fixed alkali afforded the pure argillaceous earth.

By this management he found that the Hampshire fullers earth contained of siliceous earth $51\frac{1}{10}$ parts; of mild calcareous earth $3\frac{1}{10}$; of mild magnesia $0\frac{7}{10}$; of argillaceous earth 25; of calx of iron $3\frac{7}{10}$; and of moist volatile matter $15\frac{1}{2}$ parts.

The properties required in a good fullers earth are, that it should contribute to the washing away all impurities, and promote that curling and intermixture of the hairs of the woollen cloth, which thicken its texture, and give it the desired firmness. Both probably depend on its detergent quality, that clears away all the unctuous matter of the wool, and renders its parts capable of becoming more perfectly entangled together by the mechanical action of fulling; an effect not so likely to take place when the fibres or hairs are disposed by grease to slide easily over each other. The detergent power resides in all clays, but is doubtless greatly increased by the siliceous earth, which may be considered as the brush, while the clay serves as the soap. This is familiarly shewn, by the common practice of adding sand to soap, which renders it much more detergent; but at the same time more capable of injuring the substances to which it is applied, and that more especially when the sand is coarse. Fullers earth is bad, if the sand be not exceedingly fine; and the superior excellence of the Hampshire fullers earth seems to depend more on the fineness of its parts than on their proportions, as is shewn by the experiment of boiling it in water; after which it passes more plentifully through the filter than any of the other lithomargæ.

EARTH, FUSIBLE, OF WEDGWOOD. Some mineral matter from New South Wales was put into the hands of Mr. Wedgwood*, by Sir Joseph Banks. It consisted of a mixture of fine white sand, a soft white earth, some colourless micaceous particles, and a few black ones, resembling mica or black lead. Mr. Wedgwood made some experiments upon it, but does not appear to have completely analysed the mass, probably on account of its small quantity.

Neither the nitrous nor vitriolic acids, concentrated or diluted, hot or cold,

* Philos. Transf. for 1790, page 306,

were found to take up any thing from this mineral, which could be precipitated by alkalis; excepting that the strong vitriolic acid, by due management, indicated a minute proportion of clay. But the marine acid by digestion near its boiling heat acted on it with frequent explosive bursts, and took up about one-fifth of the whole. The crude mineral pulverized, lost its blackness by calcination, and one-fourth of its weight, but was still found to be as difficult of solution as before. Water added to the marine solution threw down a white precipitate; and the separation was so complete, that, after an addition of eight or nine times the whole bulk of water, there remained nothing in solution that alkali could precipitate. This white matter was insoluble in water, and also in the nitrous or vitriolic acids, and in alkaline solutions. Strong marine acid took it up as before, with the assistance of the same degree of heat. A certain precise quantity of nitrous acid, added to the marine solution, kept the white matter suspended, even when diluted with water. Strong vitriolic acid did not throw down the white matter from the marine solution; but when the quantity added was nearly equal to that of the solution, part of the marine acid was extricated in white fumes, with effervescence. The mixture heated nearly to boiling became transparent, and continued so in the cold. This solution is also precipitable by water, and the precipitate is soluble in marine acid.

The saturated marine solution does not crystallize by evaporation, but affords a deliquescent mass, which is not corrosive, and parts with its acid in an heat near ignition. Prussian alkali does not precipitate the marine solution; but all the alkalis, whether mild or caustic, occasioned copious precipitations, which were soluble in marine acid, and thence precipitable by water in the original state.

This white precipitate is much more fusible than any of the other simple earths; whence it may with propriety be called the fusible earth, as we have ventured to denominate it in the title. In an heat between 142 and 156 degrees of Wedgwood's thermometer, which is nearly as high as the utmost heat of a small air furnace, it melted in contact with clay, with flint, with chalk, with lime, with magnesia, with pure ponderous earth, and with ponderous spar, in so many different experiments. In an hole scooped in chalk it ran into a smooth whitish opaque bead, not at all adherent to the chalk itself; and in a cavity in charcoal it likewise fused, but did not seem to undergo any revivification. Part of this was soluble in boiling marine acid, as at first; but an accident prevented the determination whether the whole was soluble.

From these experiments Mr. Wedgwood thinks it proper to consider the white matter as a new earth, directly soluble in no menstruum but marine acid, and perhaps its compounds; not crystallizable in this combination; precipitable by water, and not by Prussian alkali; parting with its acid in an heat below ignition, and fusible in a degree of heat not very much exceeding that required to melt crude iron.

The black substance which seems to have composed about one-fifth part of the crude mineral was found to resemble plumbago in its leading properties, but the residue did not appear to be iron. The remaining three-fifths of the mineral, which resisted the humid attacks in Mr. Wedgwood's experiments, were probably siliceous; but he does not speak of any direct examination of its properties, by fusion with alkalis, treatment with the acid of spar, or otherwise.

EARTH, GYPSEOUS. Before the component parts of gypsum or plaster of Paris were clearly ascertained, some chemists considered its earth as a peculiar genus. But since this compound has been proved to consist merely of lime and vitriolic acid, the term of course was rejected.

R. r

EARTH,

EARTH, OF THE JARGON. The jargon of Ceylon is a precious stone, of a pale yellowish green colour inclining to red; forming upon the whole a kind of smoky grey tinge. Its regular figure is that of a four-sided prism, terminating in two obtuse pyramids, composed each of four isosceles triangles. Its specific gravity is greater than that of any other stone, being 4,615.

Mr. Klaproth * examined this stone, and discovered a peculiar earth. Pieces of the stone were ignited, thrown into water to render it less coherent, and then levigated upon porphyry. The powder was then fused in a silver crucible with a large portion of caustic fixed alkali. The solution was treated with water and with marine acid, which took up a small part, and left a residue, which was again fused with alkali and treated as before. By several repetitions of this process the whole was dissolved. By saturating the acid with mild vegetable alkali, the earthy matter was thrown down. Digestion of part of this precipitate with marine, and part with vitriolic acid, indicated, after a due application of chemical methods, a considerable portion of siliceous earth, with a minute quantity of iron and nickel, and a much larger portion of earth, which remained suspended on account of its solubility in acids. This earth was found to differ in its properties from every other yet known. Its solubility in acids sufficiently distinguishes it from silica: when precipitated by mild alkali, it did not become effervescent like magnesia or lime; neither did it like them form Epsom salt or selenite with the vitriolic acid. It did not, like clay, form alum with that acid. Prussian alkali did not precipitate it like ponderous earth, neither did it form the ponderous spar, when combined with vitriolic acid. When this earth was treated by the blow-pipe, it was not found to be soluble either in microcosmic salt or mineral alkali; but borax dissolved it. The contents of the jargon were in the centenary $31\frac{1}{2}$ parts silica; $\frac{1}{2}$ part calx of iron containing nickel, and 68 parts of this peculiar earth.

EARTH LEMNIAN, or TERRA LEMNIA. A bolar earth from the island of Lemnos, formerly in great esteem for its supposed medical qualities. Cronstedt reckons it among the lithomargæ or stone marrow. Bergman has given a good analysis of it; for which see **EARTH, FULLERS**.

EARTH, MERCURIAL. A substance which, according to Becher and other alchemical philosophers, is a common principle of metals and some other bodies. In conformity with this obscure theory, we find frequent mention of the mercuries of gold, of silver, or of other metals. The facts and discoveries subsequent to the time of the illustrious Becher have not afforded any foundation to conclude that any such common principle as the mercurial earth exists; and it was so far from being satisfactorily exhibited by Becher himself, that his disciple, the great Stahl, did not include it in his modification of the Becherian system.

EARTH, MAGNESIAN. This earth, which is substantively called magnesia, and likewise, but not frequently, the muriatic earth, is of modern discovery. Bergman has written a treatise upon it in his usual masterly manner. It first began to be known at Rome under the name of Count Palma's powder, where it was offered by a regular canon as a remedy for all disorders. Its resemblance in many respects to calcareous earth, induced many to consider it at first as the same thing; but Mr. F. Hoffman first proved it to be essentially different. This

* See the Memoir in the Journal de Physique, for March 1790.

was afterwards discovered by Dr. Black of Edinburgh, and Margraaf of Berlin, unknown to each other.

Magnesia may be prepared in various ways; but the present is precipitated from Epsom salt by the addition of an alkali. A little more than half its weight of salt of tartar, is sufficient for this purpose; but potash is more generally used for the sake of cheapness; of which, on account of its impurity, a double quantity is required. Both the salts are to be dissolved in at least twice as much water as will suspend them. After filtration they are to be mixed and boiled, then set by at rest till the magnesia is precipitated. This, after decantation of the supernatant fluid, is to be edulcorated by several washings with water, and lastly dried upon a filter or cloth; it is the mild magnesia. Bergman informs us, that one hundred parts of Epsom salt afford about forty-two of this mild magnesia, but only twenty-five of such as does not effervesce with acids, the difference depending on the state of the precipitating alkali. If this last be mild, or contain fixed air, fifty-eight parts are necessary, and the magnesia is mild; but if it be caustic, forty-five parts will be sufficient. The double portion of water is used, in order that there may be sufficient to dissolve the vitriolated tartar, which is formed by the vitriolic acid of the Epsom salt on its union with the alkali, and the boiling is required to prevent a part of the magnesia from being suspended by a portion of the extricated fixed air.

The mother waters of nitre or sea-salt contain magnesia, which may be obtained by precipitation. The former is most impure, more especially on account of an abundant portion of lime.

The impurity of the alkalis made use of, and other circumstances, affect the magnesia to be met with in commerce. To have it pure, a solution of pure Epsom salt must be precipitated by mild volatile alkali; and the mild magnesia which falls down must be frequently washed, and then deprived of its fixed air and water by a red heat.

Mild magnesia is a light impalpable powder of a white colour, and forms a paste with water which has not much cohesion. When deprived of its fixed air by heat, it is harsher to the touch, but is not caustic nor soluble in water like lime. It does not attract fixed air so strongly as to take it from any alkali but the volatile by simple attraction. It does not precipitate lime water, but throws down all the metals from their solvents. It is very soluble in acids.

The common magnesia shews signs of fusion in a strong heat; but that which is pure resists the most powerful focus of the burning glass, without either contracting in its dimensions*, or undergoing any other change. It flows easily with borax and the microcosmic salt: with equal parts of flint and borax it assumes the form of a beautiful coloured glass, resembling the topaz. With equal parts of flint and fluor spar it affords a glass resembling the chrysolite: and with an equal portion of fluor alone it corrodes and runs through the crucible. Almost any proportion of lime, pure clay, and flint is made to flow in the fire; and with four times its weight of green glass it affords a mass resembling porcelain, and hard enough to give fire with steel. It will not flow with an equal weight singly, either of flint, quicklime, ponderous earth, glass, lead, vegetable alkali, or of vitriolated tartar. But common clay runs with it into an hard mass.

Bergman found that one hundred parts of mild magnesia contain twenty-five

* Magellan's Cronstedt, art. Magnesia.

parts acid, thirty water, and forty-five of pure magnesia; that it is sparingly soluble in water, but more plentifully when the water is impregnated with fixed air, and the magnesia very finely divided, as in the case of precipitation in the cold, by a mild alkali. Fourcroy*, who has paid particular attention to the precipitation of magnesia, found that perfectly mild vegetable alkali affords no precipitate when added to a solution of Epsom salt, at the temperature of 60°. The mineral alkali, which contains less fixed air than the crystallized vegetable alkali, was likewise found to afford but a small quantity of precipitate, unless heat was applied. Mild volatile alkali exhibited the same property. No precipitate was afforded by this salt in the cold: at a medium heat the magnesia was separated, and at a boiling heat it was again taken up, most probably in consequence of a triple combination of volatile alkali, vitriolic acid, and magnesia, having been formed. The saline combination of fixed air and magnesia was separated in crystals from all these solutions, by standing uncovered; during which time the abundant fixed air which held the magnesian salt in solution was, no doubt, gradually dissipated. The crystals afforded, when vegetable alkali was used, were contaminated with vitriolated tartar, which separates at the same time: those obtained by means of the mineral alkali are finer and purer; but the most beautiful were obtained by leaving the solution, to which volatile alkali had been added, exposed for some days in an oblong vessel.

This crystallized aerated magnesia has usually the form of six-sided prisms. It is almost tasteless, effloresces in the air, becomes pulverulent when heated, by the loss of its fixed air and water, and is soluble in about forty times its weight of water, at the temperature of 55°. Half its weight consists of fixed air, one fourth water, and one fourth magnesia. The magnesia in this salt is therefore combined with near twice as much fixed air, and more than three times as much water as are contained in the mild magnesia of Bergman.

There is scarcely any combination of magnesia which does not remarkably differ from those of lime, with which it was formerly considered to be identical. With vitriolated acid it forms Epsom salt, which is bitter and very soluble, whereas lime affords gypsum, tasteless and almost insoluble. With nitrous acid it affords a crystallizable salt. Lime does not. With marine acid it forms a combination easily deprived of its acid by mere heat. With vinegar it affords no crystals, and its elective attractions are likewise very different from those of lime. Alkalis have little or no action on magnesia in the humid way.

Magnesia combines very sparingly with sulphur in the dry as well as in the humid way, and the combination possesses the hepatic characters.

Though this earth appears to be very extensively diffused over the surface of the globe, yet it is undoubtedly less plentiful than the calcareous, siliceous, or argillaceous earths. Most of the native specimens of the magnesian genus are remarkable for a certain soapy or greasy feel. Of these the most common are steatites of a greenish colour, and soft enough to be scraped with the nail; soap rock, lapis ollaris, or Spanish chalk, of a yellow or whitish colour, or black, though rarely, rather harder than steatites, and so easily wrought and turned that pots are made of it. Asbestos, amianthus, and the Venetian and Muscovy talc are included in this genus.

EARTH PONDEROUS. This earth owes its denomination to the un-

* Annales de Chimie, ii. 282.

common weight of its combination with vitriolic acid, which is more plentifully met with than any other; and known by the names of ponderous spar, or marmor metallicum. This combination is found either transparent or opaque. The transparent spar in its usual form is of a six-sided very flat prism, ending in a four-sided pyramid; but, like all other crystals, liable to be varied by the circumstances attending their formation. The opaque specimens, called cawk by the miners, are of a white, grey, or fawn colour; frequently of no regular figure, but often in the peculiar figure of a number of small convex lenses set in a ground. Most specimens of this earth are more than four times as heavy as an equal bulk of water; which constitutes an essential difference between them and those of the calcareous genus, because these last are little more than twice the weight of the water they displace on immersion. The lime stone, or lapis hepaticus, contains about one third part of this earth. And it is also found combined with fixed air in the mine of Anglezark, near Chorley in Lancashire*, and also at Strontian and Dungleiss, near Dumbarton in Scotland.

To obtain ponderous earth in a disengaged state, the heavy spar or vitriolated ponderous may be fused with about twice its weight of mild fixed alkali, which will combine with its acid and form a neutral salt, to be washed off by water; while the ponderous earth remains behind in combination with fixed air. A strong heat drives off the fixed air, and leaves the ponderous earth in a state perfectly resembling quicklime in taste, and exhibiting the same phenomena with water. This artificial combination of fixed air and ponderous earth differs from the natural in the remarkable circumstance, that the latter contains no water; and to this it seems to be owing that the natural combination does not lose its acid by mere heat.

Great as the resemblance is between ponderous earth and lime in many respects, yet in others it differs so much as to shew that they are by no means the same substance. It is soluble in about nine hundred times its weight of water, when pure; but requires near twice as much when combined with fixed air, though an excess of this acid renders it more soluble. Its attraction to the vitriolic acid is stronger than that of any other substance, inasmuch that it affords the best test of the presence of that acid in waters or elsewhere. With the nitrous and marine salts it affords crystallizable salts. The marine solution is commonly used as the test liquor for discovering vitriolic acid. Ponderous earth affords a deliquescent salt with acetous acid. It takes the vitriolic acid from its combination with lime; and lime, on the other hand, takes the saccharine acid from its combinations.

This earth forms an hepatic combination, when treated with sulphur.

No other earth is precipitated by the Prussian alkalis; whence it has been suspected to possess a metallic nature, though no one has yet succeeded in reducing it.

It is not fusible alone by the strongest heat. The famous Bolognian phosphorus consists of the vitriolated ponderous earth ignited for a time with some combustible substance. For this purpose the spar is pulverized, then kneaded up with mucilage of gum tragacanth, and formed into pieces as thin as the blade of a knife. These pieces are afterwards dried and strongly coloured by placing them in the midst of the coals of a furnace. The pieces are cleared of the ashes by blowing on them with bellows. In this state if they be exposed to the light for a

* Manchester Memoirs, iii. 599. A very excellent analysis of this acrated ponderous earth, by Dr. Withering, is inserted in the Phil. Trans. for 1784.

few seconds, and afterwards carried into a dark place, they shine like glowing coals; they even shine under water. In process of time they lose this property; but it may be restored by a second heating. *See* BOLOGNIAN STONE.

EARTH, PORCELAIN. A fine white clay; the Kaolin of the Chinese. All natural clays contain a large proportion of siliceous earth; and the superior excellence of this clay for potters use, seems to depend in a great measure on the fineness of its siliceous ingredient. It abounds in particles of a micaceous nature; and having no oily or bituminous matter in its composition, it retains its colour in every degree of heat.

EARTH, SILICEOUS. The most eminent characters of this earth are its hardness and insolubility in almost every acid. It exists nearly in a state of purity in rock-crystal, and abounds in all natural bodies which are hard enough to strike fire with the steel. In the pulverulent form it possesses a singular degree of asperity to the touch, and has not the least disposition to adhere and become kneadable by the addition of water. It has been thought however, by Bergman and others, that water may dissolve a minute proportion of it. *See* CRYSTAL ROCK. No acid dissolves it but that of the fluor spar, which suspends it abundantly while in the aeriform state, less so when dissolved in hot water, and very sparingly when cold. Alkalis dissolve it both in the humid and the dry way. In the humid way they combine with about one-sixth part of their weight*, when the siliceous earth is in a state of extreme division. And in the dry way they take up a very large proportion, according to the degree of heat made use of. From one to two parts of alkali, with one part of flux, form hard permanent glass; but if the salt exceed this proportion, the compound will attract humidity from the air, and assume the liquid state. This fluid, or combination of flux with water by the medium of alkali, is known by the name of the liquor of flints. The addition of an acid will seize the alkali, and throw down the siliceous earth in a state of purity; and accordingly this is the process by which it is to be obtained in a disengaged state. That is to say, let rock-crystal be dissolved by strong fusion in four times its weight of fixed alkali, and the mass dissolved in water; let marine acid be then added in excess; this will seize the alkali, and form soluble salts with any other earths that may be present; but the siliceous earth will fall to the bottom. Repeated ablutions in distilled water will separate all the extraneous saline fluid which may be interposed between these particles after decantation, and the dried powder will consist of pure siliceous earth.

Pure siliceous earth has not been fused either by the heat of a furnace or of the burning mirror; but rock-crystal was fused by Professor Erhmann, by means of a flame urged by a stream of vital air. With borax it is easily fused; but requires a longer time with microcosmic salt. With metallic calces, more especially those of lead, it combines by fusion, and forms glass of a dense texture and strong refractive power. *See* GLASS.

Rock crystal, quartz, flint, gritstone, jasper, and most of the precious stones or gems, owe their distinguishing qualities to siliceous earth, and are therefore considered as specimens of this genus. The respective titles of these may be consulted for accounts of their component parts and habitudes.

EARTH, VEGETABLE. This appellation has been given to the insoluble

* Chaptal, Elements of Chemistry. Eng. Translation, ii. 15.

residue which remains after the incineration of vegetables, and likewise to the mould or soil best suited to the propagation and growth of these organized beings.

Vegetables contain but a small proportion of earth of any kind, the much greater part of their substance being found by experiment to consist of water, fixed air, and inflammable air, in the concrete or combined state, as remote principles, a small portion of fixed alkali, usually either neutralized by the vegetable acids or combined with the oils or mucilage, and a few other neutral salts.

The earth of vegetables is for the most part either calcareous, or a mixture of various earths, and sometimes of the calces of iron and manganese, in different proportions, according to the species of the vegetable. These earths may be obtained either by incineration or putrefaction, and are not therefore the product of the fire.

Vegetable mould or earth, as far as the same may consist of fixed parts, appears therefore, from these analytical facts, to be merely the vehicle by which the aqueous or aerial substances are conveyed into the vessels of plants. Other syn-
 thetical experiments of plants supported and nourished by the mere immersion in water, and some which thrive, though their roots and branches have no other body in contact with them but the air of the atmosphere, are sufficiently strong in confirmation of this truth.

Chaptal * has treated this subject in a manner so singularly perspicuous and concise, that I shall follow him in the remainder of the present article.

Although it is well proved that pure water is sufficient for the support of plants, it must not be concluded that the soil or earth is of no utility. Its use is similar to that of the placenta, which of itself affords no support to the fœtus, but prepares and disposes the blood of the mother to become a suitable nutriment; or it resembles, in its useful application, the various receptacles which are placed in the human body, to preserve the several humours, and emit them when required. The earth imbibes and retains water. It is the reservoir destined by nature to preserve the elementary fluid which the plant continually requires, and to supply it in proportion to its wants, without exposing it to the equally fatal alternatives of being either inundated or dried up.

We may even observe that the young plant or embryo of a vegetable is not entrusted by nature with the labour of digestion. The seed is formed of a parenchyma which imbibes water, elaborates it, and does not transmit it to the ger-
 men until it is converted into an humour of a suitable quality. By insensible gradations this seed is destroyed; and the plant having become sufficiently strong, is left to perform the digestive function without farther assistance. So likewise it is that we observe the fœtus supported in the womb by the fluids of the mother herself; but when it has seen the light, it receives for its nourishment a fluid less animalized; its organs are gradually strengthened, and at length become capable of digesting a stronger and less assimilated nutriment.

But on this very account, namely, that the earth is destined to afford a due supply of water to the plant, the nature of the soil cannot be a matter of indifference, but must be varied accordingly as the plant requires a more or less considerable quantity of that fluid in a given time, in proportion to the magnitude and extent of its roots.

A proper soil is that, 1st, which affords a support to the plant, of sufficient

* Elements of Chemistry, III. 26. the whole section well deserves to be consulted.

firmness

firminess to prevent its being too much agitated, or overthrown, by the winds or other causes; 2d, which is capable of admitting the roots to be easily extended; 3d, which is suited to receive and absorb moisture, that the plant may on no occasion suffer from the want of this essential requisite. To answer these conditions, it is necessary to make a due mixture of the primitive earths, because no one in particular is equal to the accomplishment of them. Siliceous and calcareous earths may be considered as hot and drying, the argillaceous as moist and cold, and the magnesian as possessing intermediate properties. Each in particular has its imperfections that render it unfit for culture. Clay absorbs water, but does not communicate it; calcareous earth receives and gives it too quickly; but the properties of these earths are so happily opposed that they correct each other by mixture. Accordingly we find, that by adding lime to an argillaceous earth, this last is divided; and the drying quality of the lime is mitigated, while the stiffness of the clay is diminished. On these accounts also it is that any single earth cannot constitute manure to be applied in all cases; but the character of the soil intended to be meliorated, ought first to be examined and considered before any decision is made concerning the manure to be applied. M. Tillet has ascertained, that the best proportions of a fertile earth for corn, are three-eighths clay, two-eighths sand, and three-eighths fragments of hard stone.

The advantage of labour or cultivation consists in dividing the earth, impregnating it with air, destroying useless and noxious plants, and converting them into manure by facilitating their decomposition. See ARABLE LAND.

EARTH, VITRIFIABLE. Every earth is in fact vitrifiable with proper additions, and none without, except the new fusible earth. But siliceous earth has been rather generally distinguished by this name, on account of the superior facility with which it is converted into a good glass by fusion with an alkali. See EARTH SILICEOUS, *also* GLASS.

EARTHWORMS are plentifully found in moist fat grounds, but rarely, if ever, in dry sands. M. Reaumur proposed collecting them as a cheap substitute for grain in feeding domestic poultry. The physicians, who appear to have overlooked scarcely any produce of the three kingdoms of nature, have used these creatures, under the notion of their possessing an antispasmodic and diuretic virtue. Neumann relates several experiments made with them. They are cleansed by washing, and suffering them to creep through dry woollen cloths. Unless hastily dried by the heat of the sun or a fire, they are very apt to putrefy. Moistened with wine or vinous spirit, to prevent their putrefaction, and set in a cellar in a wide-mouthed glass, they are almost wholly resolved in a few days into a slimy liquor. When this liquamen or solution is mixed with a little fixed alkali, and after due evaporation set by to shoot, the crystals are no other than saltpetre. Neumann did not in direct terms assert that he himself made this experiment, and from the context there seems to be some slight reason to suspect he had it from Stahl.

He made however his usual set of experiments with them by digestion in water and ardent spirit, and by destructive distillation. When repeated digestion with the spirit was used first, the quantity of extract from four ounces of the dried worms, and the residuum treated with water, yielded three drams and a scruple. But the same quantity treated first with water, afforded one ounce, six drams, and a scruple, after which rectified spirit extracted two scruples.

Thirty-two ounces of dried earth-worms yielded, by destructive distillation, thirteen ounces and a half of an alkaline fluid, one ounce of concrete volatile alkali,

alkali, and four ounces and a half of empyreumatic oil. The remainder burned in the open air afforded, by lixiviation, one ounce and a half of fixed alkali. The earthy residuum weighed six ounces and a half, which, at that early period of chemistry, Neumann did not possess the methods of examining. If the worms were putrefied by distillation, the volatile product was scarcely any thing but mere water, with very little oil and volatile alkali.

EAU DE LUCE. The smell of the volatile alkali is rendered considerably more grateful by an imperfect combination with oil. Eau de luce is a compound of this nature, consisting chiefly of the essential oil of amber and the volatile alkali. There is some difficulty in compounding this fluid, so that it shall possess the desired quality of a beautiful milky whiteness. For if the combination be too perfect by a due proportion of the materials, it will approach to transparency; and if it be less perfect by a redundancy of oil, this last will separate in the form of globules, or in a kind of cream. Macquer* speaks highly of the following receipt, taken from the French edition of the London Dispensatory.

Take four ounces of rectified spirit of wine, and in it dissolve ten or twelve grains of white soap; filter the solution, then dissolve in it a dram of rectified oil of amber, and filter again. Mix as much of this solution with the strongest spirit of sal ammoniac or pure volatile alkali, in a flint glass bottle, as, when sufficiently shaken, shall produce a beautiful milky fluid. If a cream be formed on its surface, some more of the oily spirit of wine must be added.

ECHINI. Calcareous petrifications of the echinus, or sea hedgehog.

EDULCORATION. This word imports the same thing as dulcification, properly speaking; namely, the rendering things more mild: but chemists use the terms very differently. Dulcification consists in the obtunding of acids by combination with ardent spirit (see the word). Edulcoration consists in carrying off superfluous acid, or other saline matter, by one or more washings with water. Metallic calces and other insoluble precipitates are usually edulcorated previous to drying them.

EFFERVESCENCE. According to its derivation, this term implies the boiling over of any fluid by heat. In chemistry it is appropriated to the commotion and increase of volume produced in fluids by some part of the mass suddenly taking the elastic form, and escaping in numerous bubbles. Thus, when an acid is poured on chalk, the fixed air is disengaged in the elastic state with bubbles, vapour, and an hissing noise.

Effervescences are more or less violent, according to circumstances, and are usually attended with a change of the temperature. If the capacity of the mixture or new combination for heat be diminished by the change the bodies have undergone, in a greater degree than that of the elastic fluid is enlarged, the temperature will be increased: but if, on the contrary, the mixture retain its original or acquire an increased capacity, the elastic fluid will carry off so much of the heat as to produce a greater or less degree of cold in the remainder. Chemistry affords many instances of both effects taking place.

EFFLORESCENCE is the effect which takes place when solid or consistent bodies gradually and spontaneously become converted into a powder. It is almost always occasioned by the loss of the water of crystallization in saline bo-

* Chemical Dictionary, art. Eau de Luce.

dies. Thus the mild mineral alkali, Glauber's salt, martial vitriol, and many other salts, are efflorescent ; that is, they become dry and pulverulent, when left exposed to the air. Other efflorescences are occasioned not simply by the loss of moisture, but by processes of a more compounded nature, such as the efflorescence of vitriolated clay or alum-slate by the conversion of its sulphur into vitriolic acid, by roasting and exposure to the air, or the efflorescence of the martial pyrites, which by the same treatment become converted into green vitriol, though originally composed of sulphur and iron.

EGGS. The eggs of hens and of birds in general are composed of several distinct substances. 1. The shell or external coating, which is composed of lime and phosphoric acid, and consequently of the same nature as bones, though its thinness and extreme porosity render it apparently more brittle. 2. A thin white and strong membrane, possessing the usual characters of animal substances. 3. The white of the egg, which is an adhesive, transparent, and imperfectly fluid substance, becoming opaque and hard by a degree of heat which does not deprive it of any weight, diffusible in water, and separable by the same coagulating mediums as separate the curd of milk, from which, according to Scheele, it does not at all differ. *See* CHEESE. Both these substances possess the quality of serum, which is diffusible in cold water, and coagulates by heat, and accordingly the refiners of sugar and other manufacturers use either eggs or blood almost indiscriminately in clarifying their solutions. For the white of egg, when it assumes the solid form, rises to the top, in the form of skum, carrying the gross impurities along with it, probably by a mere mechanical colation or straining. 4. The yolk, which appears to consist of an oil of the nature of fat oils, united with a portion of ferous matter, sufficient to render it diffusible in cold water, in the form of an emulsion, and concrescible by heat. Yolk of egg is used as the medium for rendering resins and oils diffusible in water. An oil of eggs is procured by expression from the yolks of eggs, previously roasted to deprive the ferous part of its fluidity. A slight empyreuma is given to the oil by this treatment, which might probably be avoided by applying no greater heat than on trial might be found sufficient to coagulate the serum.

The products afforded by the several parts of eggs, subjected to destructive distillation, are nearly the same as are obtained by that method from other animal matters.

Mr. Reaumur found that eggs might be preserved during months or years, by being covered with mutton suet, or any other fat substance.

ELECAMPANE. Neumann distilled thirty-two ounces of the root, and obtained three scruples and a half of oil, part of which stuck in the head of the still, and part passed down into the receiver, along with the water made use of. He did not obtain a concrete of this nature from any other vegetable. It resembles camphor in some respects, but not in all. Water does not affect it. Ardent spirit totally dissolves it. When laid on burning coals, it exhales without leaving any residue. Held over a gentle fire in a ladle, it flows like wax or tallow, and when cold, appears softer and more unctuous than at first. The younger Geoffroy observes that this matter resides in the exterior parts of the root near the bark.

Rectified spirit distilled from the root carries nothing over, and water leaves more behind it than it takes up. One ounce of the dry root afforded six drams and a half of extract with water ; but the same quantity with spirit gave only two drams and a half with spirit.

ELECTRUM. Amber. See the article.

ELEMENTS. A term used by the earlier chemists, nearly in the same sense as the moderns use the terms first principle. The chief, and indeed very essential difference between them is, that the ancients considered their elements as bodies possessing absolute simplicity, and capable of forming all other bodies by their mutual combination; whereas the first principles of the moderns are considered as simple, merely in respect to the present state of the art of analysing bodies. That is to say, the ancients almost totally overlooked the imperfection of the art in their general deductions; but the moderns pretend to keep it in view.

The experiments made in the infancy of chemistry had for their object, the phenomenon of combustion, referred by them to a substance called fire; the extrication of elastic fluid, considered to be of the same nature as the immense mass which composes the atmosphere; water, neither compoundable nor destructible by any experiments then known or understood; and substances not volatile in the strongest heat of furnaces, confounded by them, with a few exceptions, under the general term of earth. In this way they obtained four elements or first principles, fire, air, water, and earth.

Subsequent experiments and enquiries have multiplied the number of elements, and have alternately shewn the inutility of any exclusive general arrangement of bodies, as absolutely simple, because not yet analysed. *See PRINCIPLES; also* ATTRACTION.

ELIQUATION. An operation, by means of which a more fusible substance is separated from another which is less fusible. It consists in the application of a degree of heat sufficient to fuse the former, but not the latter. It may be effected either by using a perforated crucible, or in the large way, by a furnace constructed to answer the same purpose. In order that a separation may follow by this method, it is necessary that the combination between the two substances should be by no means intimate. Thus sulphur may be separated from its earthy admixtures by the gentle heat necessary to fuse it; but it cannot, in the same manner, be separated from its metallic combinations. So likewise lead may be separated by eliquation from copper; but tin cannot.

ELUTRIATION. This word is used by chemists to denote the process of washing, as practised by metallurgists and others; and indeed this last and more familiar term is most frequently used. Thus the metallic ores are cleared of earthy admixtures by elutriation, that is to say, washing with water, which carries off the lighter earthy parts, while the heavier metallic parts subside to the bottom.

EMERALD. A transparent precious stone, of a green colour, nearly of the same hardness as the garnet, or agate; but inferior to the topaz and ruby. In its rough, or native state, it consists of six-sided prisms, commonly truncated at both ends. Engestrom says, that they become of an opaque white in a strong fire, without the least mark of fusion: but Wallerius asserts, that this stone, when heated to a white heat, becomes of a deep blue colour, and phosphorescent, and recovers its green colour when cold. From these facts it seems probable, that the experiments of these two naturalists were made with different kinds of emeralds; or else, that the white colour in the former experiments might arise from an infinity of flaws produced by the sudden application of heat. Friction produces electricity in the emerald. Some emeralds, of the dark green sort, resemble the

tourmalin in the property of attracting small bodies, by an electricity produced by heating and cooling.

When crystallized cockle, or shirl, is found of a green colour, transparent, and free from cracks or flaws, it is commonly called emerald by the jewellers, though it is generally of a deeper colour than the true emerald, and also wants their lustre; and hence it is, that the cockle spar from Egypt is called the mother of emeralds. However, it is probable that this cockle was, in ancient times, fashionable in Egypt, under the name of emerald, though at present it is not so much valued as the emerald of this (siliceous) kind.

The true emerald is not acted upon by mineral alkali in the dry way, but it yields to borax and microcosmic salt, with which, according to Quist and Wallerius, it affords a colourless glass.

According to Bergman's analysis, 100 parts of this stone contain 60 of clay, 24 of silic, 8 of lime, and 6 of iron. By Mr. Achard's analysis, the component parts were nearly the same.

EMERY. I do not know of any analysis of this substance. The best sort is of a dark grey colour, but becomes brown, and in a great measure magnetical, by calcination. Other sorts are of a reddish rusty white or yellowish colour. This mineral scarcely yields to any substance in hardness, excepting the diamond. It is much used for grinding and polishing. Mr. Kirwan thinks that it consists of a mixture of the red and white calces of iron with some unknown stony substance, perhaps tripoli.

EMPYREUMA. This term is applied to denote the peculiar smell produced by a considerable heat upon vegetable or animal substances, in closed vessels, or when burned under circumstances which prevent the access of air to a considerable part of the mass, and consequently occasion an imperfect combustion, or destructive distillation of the parts so covered up by the rest of the mass.

Mr. Macquer observes, that empyreuma is the peculiar smell of burned oils, and that no other but oily substances can produce it. He even proposes this indication as a test of the presence of oil, in bodies which contain too small a quantity of that fluid to admit of any other way of exhibiting it.

EMULSION. An imperfect combination of oil and water, by the intervention of some other substance, capable of combining with both these substances. The substances are either saline or mucilaginous. Thus the volatile alkali with certain management forms the emulsive liquor called volatile liniment and eau de luce. Gum arabic, or sugar triturated with oils, renders them miscible with water, as do likewise white of egg and other animal mucilages. The vegetable juices obtained by compression from various seeds and other parts of vegetables, are of an emulsive nature. But it does not seem probable that they exist in the vegetable under the emulsive form, but rather that the several distinct vessels respectively contain oil, water, mucilage, or sugar, the confused mixture of which produces the emulsion. On the same principle it seems to be, that the gum resins afford emulsions when triturated with water.

Sir Isaac Newton has shewn by experiment that all bodies are transparent, whose particles do not exceed a certain magnitude, which he has deduced by computation in his *Optics*. When opacity is the result of a combination of two transparent bodies, it affords a considerable proof, that their union is little more than mechanical. It is well known how slowly small particles either sink or arise to the surface of any fluid in which they may be suspended. Atwood, in his

Treatise on the rectilinear and rotatory Motion of Bodies, and other writers, have shewn the methods of ascertaining these velocities, when the densities of the particles and of the fluid, together with the magnitude of the former, are known. Whence it is not to be wondered, that a slight tendency to chemical combination, assisted by minute mechanical division, should occasion the respective parts of enulsive liquors to remain for a long time without separation. It is found, however, that in process of time they do separate.

ENAMELLING. The art of enamelling on metals is treated at full length by Mr. Brougniart, in the 9th volume of the *Annales de Chimie*, from whom I shall take the greatest part of this article.

Neri on Glafs, with the notes of Merret and Kunckel, afford a variety of good receipts for making enamels, though much still remains to be done in this art. The art is indeed retarded by the considerable advantage the enameller derives from a discovery of any colour uncommonly brilliant, clear, or hard. On this account the artist naturally endeavours to keep his process a secret, as the source of private gain. The principal ingredients of enamel colours are, however, well known.

There are two kinds of enamel, the opaque and the transparent. Transparent enamels are usually rendered opaque by adding putty, or the white calx of tin, to them. The basis of all enamels is therefore a perfectly transparent and fusible glass. The calx of tin renders this of a beautiful white, the perfection of which is greater when a small quantity of manganese is likewise added. If the calx of tin be not sufficient to destroy the transparency of the mixture, it produces a semi-opaque glass, resembling the opal.

Yellow enamel is formed by the addition of calx of lead, or antimony. Kunckel likewise affirms, that a beautiful yellow may be obtained from silver.

Red enamel is afforded by the calx of gold, and also by that of iron. The former is the most beautiful, and stands the fire very well, which the latter does not.

Calx of copper affords a green; manganese, a violet; cobalt, a blue; and iron, a very fine black. A mixture of these different enamels produces a great variety of intermediate colours, according to their nature and proportion. In this branch of the art, the coloured enamels are sometimes mixed with each other, and sometimes the calces are mixed before they are added to the vitreous bases.

The enameller, who is provided with a set of good colours, is very far from being in a situation for practising the art, unless he be skilled in the methods of applying them, and the nature of the grounds upon which they are to be laid. Many of the metals are too fusible to be enamelled, and almost all of them are corroded by the action of the fused glass. For this reason, none of the metals are used but gold, silver, and copper. Platina has indeed been used; but of its effects and habitudes with enamels, very little can be said, for want of a sufficient number of experiments.

The purest gold of 24 carats is calculated to produce the best effect with enamel. 1. Because it entirely preserves the metallic brilliancy without undergoing any calcination in the fire. 2. Being less fusible, it would admit of a more refractory, and consequently a harder and more beautiful enamel. It is not usual, however, to enamel upon finer gold than 22 carats; and the operation would be very defective, if a coarser kind than that of 18 carats were used. For in this case more alkali must be added to the enamel, to render it more fusible, and this addition would at the same time render it softer and less brilliant.

Rejecting

Rejecting all these exceptions, the author gives the following description, by way of example, of fixing a transparent blue enamel upon gold of 22 carats.

The artist begins his operation by breaking the enamel into small pieces in a steel mortar, and afterwards pulverising it in a mortar of agate. He is careful to add water in this part of his process, which prevents the splinters of glass from flying about. There are no means of explaining the point at which the trituration ought to be given up, as this can be learned only by experience. Some enamels require to be very finely tritured; but others may be used in the form of a coarse powder. As soon as he apprehends that his enamel is sufficiently pounded, he washes it by agitation in very clear water, and pouring off the fluid as it becomes turbid. This operation, which is made for the purpose of carrying off dust and every other impurity from the enamel, is continued until the water comes off as clear as it was poured on.

The workman puts his enamel, thus prepared, in a white china or earthen faucet, with water poured on it to the depth of about one tenth of an inch. He afterwards takes up this enamel with an iron spatula, as equally as possible. As the enamel here spoken of is transparent, it is usual to ornament the surface of the gold with rose work, or other kinds of work, calculated to produce a good effect through the enamel.

The thickness of this first layer depends entirely upon its colour: delicate colours, in general, require that it should have no great thickness.

The moist enamel being thus placed, is dried by applying a very clean half-worn linen cloth to it, which must be very carefully done, to avoid removing the enamel by any action of wiping.

In this state the piece is ready for the fire. If it be enamelled on both sides, it is placed upon a tile, hollowed out in such a manner, that the uncovered edges of the piece alone are in contact with the iron. But if it be enamelled on one side only, it is simply laid upon the plate, or on a tile. Two things, however, require to be attended to. 1. If the work be very small, or not capable of being enamelled on its opposite side, the iron plate must be perfectly flat, in order that the work may not bend when softened by heat. 2. If the work be of considerable size, it is always counter-enamelled if possible; that is to say, an enamel is applied on the back surface, in order to counteract the effect which the other coating of glass might produce on the soft metal, when it came to contract by cooling.

The enamellers furnace is square and built of bricks, bedded in an earth proper for the purpose. It may be considered as consisting of two parts, the lower part, which receives a muffle, resting on the floor of the furnace, and open on both sides.

The upper part of the furnace consists of a fire-place, rather larger and longer than the dimensions of the muffle. This fire-place contains the charcoal, which must surround the muffle on all sides, excepting at the bottom. The charcoal is put in at a door above the muffle, and which is closed when the fire is lighted. A chimney proceeds from the summit of the furnace with a moderate aperture, which may be closed at the pleasure of the artist, by applying a cast iron plate to it. This furnace differs from that of the assayer in the circumstance that it is supplied with air through the muffle itself: for if the draught were beneath the muffle, the heat would be too strong, and could not be stopped when requisite.

As soon as the fire is lighted, and the muffel has obtained the requisite degree of ignition, the charcoal is disposed towards the lower part of the muffel in such a manner as that it shall not fall upon the work, which is then conveyed into the muffel with the greatest care upon the plate of iron or earthen ware, which is taken up by long spring pinchers. The work is placed as near as possible at the further extremity of the muffel; and as soon as the artist perceives a commencement of fusion, he turns it round with great delicacy, in order that the fusion may be very uniform. And as soon as he perceives that the fusion has completely taken place, he instantly removes it out of the furnace: for the fusion of gold happens so very near that of the enamel, that a neglect of a few seconds might be attended with considerable loss.

When the work is cooled, a second coat of enamel is applied in the same manner as the first, if necessary. This, and the same cautious management of the fire, are to be repeated for every additional coat of enamel the nature of the work may demand.

As soon as the number of coatings are sufficient, it becomes necessary to give an even surface to the enamel, which, though polished by the fire, is nevertheless irregular. This is done with an English fine-grained file and water. As the file wears smooth, sand is used. Much precaution and address are required in this part of the work, not only because it is easy to make the enamel separate in splinters from the metal, but likewise because the colour would not be uniform if it were to be ground thinner at one part than at another.

The deep scratches of the file are in the next place taken out, by rubbing the surface with a piece of deal wood and fine sand and water. A polish is then given by a second ignition. This polish, however, is frequently insufficient, and not so perfectly uniform as the delicacy of the work may require.

The substance used by the enamellers, as a polishing material, is known by the name of rotten-stone; which is prepared by pounding, washing, decanting off the turbid water, suffering the fine suspended particles to subside from this water, and lastly levigating it upon a glass plate.

The work is then cemented to a square piece of wood with a mixture of rosin and brick-dust, and by this means fixed in a vice.

The first operation of polishing is made by rubbing the work with rotten-stone upon a small strait bar of pewter. Some delicacy is here required, to avoid scratching or producing flaws in the enamel, by pressing it too hard. In this way the piece is rendered perfectly even: but the last brilliant polish is given by a piece of deal wood and the same rotten-stone.

This is the general method of applying enamels; but some colours require more precaution in the management of the fire. Opaque colours require less management than the transparent. A variety of circumstances must be attended to in the management of transparent colours; every colour requires gold of a particular fineness.

When different colours are intended to be placed beside one another, they are kept separate by a small edge or prominency, which is left in the gold for that purpose, and is polished along with the enamel.

The enamelling upon silver is effected nearly in the same manner as that of gold; but the changes sustained by the colours upon the silver, by the action of fire, are much more considerable than when gold is used.

Copper

Copper is not much used by enamellers, on account of the difficulty which attends the attempt to fix beautiful colours upon it. When this metal is used, the common practice is to apply a coating of opaque white enamel, and upon this other colours which are more fusible than the white.

A good effect is produced in toys, by leaving part of the gold bare. For this purpose its surface is cut into suitable compartments by the engraver. This, however, is an expensive method, and is for that reason occasionally imitated by applying small and very thin pieces of gold upon the surface of the enamel, where they are fixed by the fire, and afterwards covered by a transparent vitreous coating.

After this detail of the art of enamelling, Mr. Brougniart describes a method of taking off the enamel from any toy, without injuring its metallic part. For this purpose, a mixture of common salt, nitre and alum in powder, is applied upon the enamel, and the piece put into the furnace. As soon as the fusion has taken place, the piece is suddenly thrown into water, which causes the enamel to fly off either totally or in part. The part which may remain is to be removed by repeating the same operation a second time. See GLASS; also POTTERY.

ENS MARTIS. A name anciently given to the calx of iron which arises in sublimation, with twice its quantity of sal ammoniac. Medical practice does not at present place this preparation in a higher rank of estimation than other calces of iron.

ENS VENERIS. The ens martis is in many dispensatories called by this name; others direct a sublimation to be made with sal ammoniac, and the calx of cupreous vitriol, a process which it is well known affords no flowers, or at least a quantity proportioned merely to the iron with which the vitriol of copper may be contaminated. It appears, therefore, that there is no ens veneris.

ENTROCHI. A genus of extraneous fossils, usually of about an inch in length, and made up of a number of round joints, which, when separate and loose, are called trochitæ: they are composed of the same kind of plated spar with the fossil shells of the echini, which is usually of a blueish grey colour; and are very bright where fresh broken: they are all striated from the centre to the circumference, and have a cavity in the middle. They seem to be the petrified arms of that singular species of the sea star-fish, called *Stella Arborefcens*.

ESSAY. See ASAY.

ESSENCES. Several of the volatile or essential oils are called essences by the perfumers.

ETHER. A very volatile fluid, produced by the distillation of ardent spirit with an acid. The vitriolic ether is upon the whole best known, though there are various ethers made by means of other acids. As some advantages may be gained by treating of the whole under one article, I shall accordingly pursue that method.

Various passages in the writings of the earlier chemists sufficiently evince, that the vitriolic ether was among their secrets; but it was scarcely attended to before the year 1730, when a certain quantity was presented to the Royal Society by Dr. Frobenius, and certain experiments were made of its most obvious qualities.

When strong vitriolic acid is poured upon an equal measure of rectified spirit of wine, the fluids unite with an hissing noise and the production of heat, at the same time that a fragrant vegetable smell is perceived, resembling that of apples. It is much better and safer, however, to add the acid by small portions at a time,

at

at such intervals of time, as that no perceptible heat may be produced. The mixture may be made in a glass retort, and the distillation performed by regulated heat on a sand-bath, a large receiver being previously well adapted and kept cool by immersion in water, or the frequent application of wet cloths. The compound apparatus, fig. 2. plate I. may be advantageously used in this as in other distillations. The first product is a fragrant spirit of wine, which is followed by the ether, as soon as the fluid in the retort begins to boil. At this period the upper part of the receiver is covered with large distinct streams of the fluid, which run down its sides. After the ether has passed over, volatile sulphureous acid arises, which is known by its white fumes and peculiar smell. At this period the receiver must be unluted and removed, care being taken to avoid breathing the penetrating fumes of the acid; and the fire must at the same time be moderated, because the residue in the retort is disposed to swell. A light yellow oil, called sweet oil of wine, comes over after the ether, and is succeeded by black and foul vitriolic acid. The residue varies in its properties according to the management of the heat. If the fire be much increased towards the end of the process, the volatile vitriolic acid that comes over will be mixed with vinegar. If the remaining fluid contained in the retort after the ether has passed over, be not urged further, it may be made to afford more ether by the addition of one-third of very strong spirit; and this may be repeated successively, with less quantities, until near twice the quantity of the spirit originally made use of has been added.

The ether comes over mixed with spirit of wine and some volatile vitriolic acid. It was usual to add some distilled water to this product, which occasioned the ether to rise to the top. Rectification is absolutely necessary if the ether have a sulphureous smell; and this is indeed the better method in all cases, because the water added in the old method always absorbs about one tenth part of its weight of ether, which cannot be recovered without having recourse to distillation; and also, because the ether is found to absorb a quantity of the water. Simple rectification, with the addition of a little lime or alkali, and by a gentle heat, is therefore preferable.

Dr. Hopson, in his General System of Chemistry, taken chiefly from Weigleb *, has given a very copious abstract of the experiments on ethers of M. Dollfus, related by him in his *Pharmaceutisch-Chemische Erfahrungen* ed Leipzig, 1787, which well deserves to be consulted, and to which the reader is referred for fuller information on this subject. The inexperienced chemist must, however, be reminded, that the extreme inflammability of ardent spirit, and still more of ether; the danger of explosion which attends the sudden mixture and agitation of concentrated acids and ardent spirit; and the suffocating effect of the elastic fluids, which might fill the apartment if inadvertently disengaged; are all circumstances which require cautious management.

Vitriolic ether is one of the lightest and most volatile of all non-elastic fluids. Its dissipation into the air by evaporation is so sudden as to produce extreme cold. It is highly inflammable, burns with a more luminous flame than ardent spirit, and emits more smoke.

The action of this fluid upon saline substances has been little attended to. It does not appear to act upon lime or fixed alkalis. Caustic volatile alkali com-

* Page 511.

bines with it in all proportions. Vitriolic acid combines with it, and extricates heat; and from this compound the sweet oil of wine may be obtained by distillation. Nitrous acid causes an effervescence, and renders it more oily. It dissolves camphor very plentifully.

Nitrous acid has so strong a disposition to combine with ardent spirit, that a considerable danger of explosion attends the mixture of these fluids. Both these circumstances have given rise to a number of processes for forming nitrous ether. It has been made by mixing the two fluids in a retort, connected with very capacious receivers; a method in which it is probable, that no ordinary degree of precaution would be sufficient to secure the operator from the danger of the vessel's being blown in pieces by the elastic fluid that is so suddenly extricated. It may also be obtained without distillation, from a mixture of nitrous acid and ardent spirit. For this purpose, six ounces of highly rectified spirit of wine are put into a strong bottle, capable of containing one pound of water, and immersed up to the neck in a vessel of very cold water, in which it will be advantageous to put three or four pounds of ice, broken small. Upon the spirit, in this situation, and kept continually agitated, four ounces of nitrous acid of the specific gravity of 1.5, are to be poured, in four or five successive portions, or even more gradually. As soon as the mixture is completed, the bottle must be closed with a good cork, secured with leather and packthread, or wire; and the whole must be left in a place where it may remain undisturbed, no other attention being necessary than that of renewing the water from time to time, as it may become heated. In the course of two or three hours the transparency of the fluid becomes troubled by an infinity of drops of ether, which are disengaged from every part of its volume. This ether gradually rises to the surface, and at the end of twenty four hours it may be separated from the rest of the liquor by means of a funnel. In opening the phial, it is necessary first to pierce the cork with a pointed instrument, in order that a quantity of elastic fluid may escape, which might otherwise suddenly follow the cork, and carry part of the fluid along with it. The quantity of ether obtained in this way will be about four ounces. Its colour is of a light orange, and part is disposed to escape with effervescence, whenever the bottle which contains it is unstopped. This seems to arise from a portion of uncombined acid contained in the fluid. It must be rectified in order to have it pure; and in this process it loses near half its weight.

The danger attending the making of nitrous ether is less when the acid is diluted. The method of Dr. Dehne, as described by Weigleb*, though he uses concentrated acid, appears to be very safe. This chemist put two pounds of pure ardent spirit into a tubulated retort, to which a large receiver was luted, and added to this half an ounce of fuming nitrous acid every four hours, drop by drop. Twelve ounces of the acid having been introduced in this manner into the retort, and half an ounce more being added, the mixture began to throw up small bubbles, though without producing any heat, and twelve hours elapsed before all was quiet again. By this means about an ounce of ether came over into the receiver, which, on the farther addition of nitrous acid, received an increase. After this, two drams of the acid only were added morning and evening. On the eighth day, after the first addition, a greenish ether was seen to cover the liquor in the retort, to the depth of about half an inch; but the addition of

* General System of Chemistry, by Hopson, page 514.

nitrous acid was still continued, till on the twelfth day one pound and five ounces of nitrous acid had been introduced into the receiver. The mixture then began to be affected with a brisker motion, when the ether was taken off, and weighed one pound and one ounce. Upon the residuum he then poured, drop by drop, as before, two drams of nitrous acid morning and evening, till the acid fell to the bottom in the form of perfectly green globules. Dr. Dehne, in consequence of much experience, affirms, that these bubbles are a sign that no more ether will be separated by any subsequent addition of nitrous acid; but that the mixture is saturated with nitrous acid, and will yield no further produce, unless ardent spirit be added. The quantity of ether separated the second time, amounted to eight ounces and three drams. So that the whole produce of ether was one pound, nine ounces, and three drams, afforded by adding one pound, ten ounces, and three drams of nitrous acid to two pounds of ardent spirit. The residuum weighed one pound twelve ounces, and five ounces were lost, which was probably ether. The operation succeeds best in cold weather; and it has frequently been observed, that ardent spirit, distilled from oily bodies, yields more ether than when pure. This nitrous ether, like the foregoing, is commonly still acid, and may be treated with a solution of alkali, and subsequent rectification.

We shall barely mention the other less direct processes for forming nitrous ether: 1. A mixture, of two parts vitriolic acid and four ardent spirit, added to four parts dry nitre, affords by distillation a dulcified nitrous acid, mixed with ether, of which two parts may be had by rectification *. 2. If nearly one part of diluted nitrous acid be carefully poured upon two parts of dense nitrous acid; and upon this there be poured, with the same caution, three parts of strong ardent spirit; and this compound fluid be left to stand in a phial loosely corked, the acid and spirit will gradually act upon each other, and ether will in a day or two be formed at the top. The whole being put into a retort, affords two parts and more of very pure ether, by distillation. 3. If nitrous acid be disengaged in the usual way from nitre by the addition of vitriolic acid, and the acid which comes over be received into ardent spirit, this last will become in part converted into ether, which may be separated by rectifying. The method is said to be attended with some danger.

In certain proportions of the materials, and by due management of the process for making nitrous ether, the nitrous acid wholly disappears, and the residue is found to contain no nitrous acid, but some vinegar and the acid of sugar.

Rectified nitrous ether burns with a flame rather more luminous than that afforded by the vitriolic ether, at the same time that it gives out rather more smoke, and leaves a black trace behind. In other respects it very much resembles the vitriolic ether.

The methods of making marine ether consist in applying the marine acid, in the dephlogisticated or aerated state, to ardent spirit; for, in the common state of the acid, their mutual action is little or none. In Mr. Westrumb's method, it is procured from four ounces of common salt, two of powdered manganese, two of vitriolic acid, and six of ardent spirit, by means of distillation. The liquor being distilled to dryness, is poured back upon the residuum, and distilled afresh. In this distillation, nearly the half which comes over is dulcified marine acid, and most of the other half marine ether, which may be separated from the rest by the addition of water.

* Dollfus.

Marine ether is very transparent and volatile, and burns with a smoke and suffocating smell. Many chemists doubt the existence of marine ether, and assert, that the product which is so called is merely a dulcified spirit.

It is a question whether any ether can be produced by the direct application of the acetous acid to ardent spirit. It appears to be a condition, that the acid should be in the aerated state; and as it appears to exist in this state (usually called radical vinegar), in most salts the ethereal combinations are best effected in the indirect methods. According to Westendorf's recipe, equal parts of the strongest spirit of vinegar (probably the radical vinegar) and ardent spirit are mixed together, and suffered to stand for some days in a well-stopped glass vessel, until the mixture has acquired a peculiarly agreeable smell. The liquor is then to be poured into a retort with a receiver accurately luted on, and nearly the half is to be drawn off by a gentle heat. One sixteenth part of fixed alkali, dissolved in four times its weight of water, is to be added to the distilled product, and the fluid gently agitated with a circular motion, which will cause the ether to rise and float at the surface like oil, whence it may be taken off. Its quantity commonly amounts to half that of the ardent spirit employed. Half the original quantity of ardent spirit may be again added to the acetous residue once or twice more, by which means the ethereal product will be still more augmented.

Various methods are given of producing acetous ether by the decomposition of an acetous neutral salt, by the addition of a mineral acid. Thus, if an ounce of alkali saturated with vinegar be dissolved in three ounces of ardent spirit, and a little more of any mineral acid be added than is requisite to saturate the alkali, and the mass be then distilled, acetous ether will be obtained. Or if eight ounces of sugar of lead be gently dried to deprive it of its water of crystallization, which amounts to rather more than one fourth of its weight; if in this state it be put into a glass retort, and a mixture of five ounces of vitriolic acid, and eight ounces of spirit of wine, be poured on it, and the whole be exposed to distillation by a very gentle heat; the first ounce that passes over will consist of dulcified acetous acid, the next ounce will be almost all ether, and the whole quantity of ether produced will be near four ounces.

Acetous ether is not nearly so volatile as the nitrous or vitriolic. It burns with a blue flame like ardent spirit.

The acid obtained by distillation from wood likewise affords an ether remarkable in its quantity, which considerably exceeds that of the ardent spirit made use of*. For this purpose the acid may be distilled from beech wood, rectified a second time, and then saturated with fixed alkali. Three pounds of the acid require about five ounces of purified alkali (I suppose mild). By evaporation to dryness, slight fusion, with subsequent solution, filtration, and evaporation, three ounces and a quarter of a foliated neutral salt are obtained. The concentrated acid of wood may be disengaged from this by distillation with two ounces of vitriolic acid; and the quantity of acid of wood thus obtained weighs one ounce and three quarters. By mixing this with an equal quantity of pure ardent spirit, and distilling with a small retort, near two ounces and a quarter of ether are obtained.

A mixture of one ounce of the distilled acid of wood sorrel with an equal quantity of ardent spirit, afforded by distillation three drams of ether, in the

* Weigleb, p. 521.

hands of Savary. The crystallized saccharine acid distilled with an equal portion of ardent spirit, afforded Bergman, first, ardent spirit, then an acid liquor, which by evaporation yielded crystallized saccharine acid and precipitated lime-water, and on the top of which floated a thin stratum of ether, that acquired a blue tinge from calx of copper, and did not take fire until previously heated. Its flame was blue.

An ethereal liquor was obtained by Crell, by gentle distillation of equal parts of acid of fat and ardent spirit. The phosphoric acid does not produce ether by direct combination with ardent spirit; but the combination is said to take place by distilling a due mixture of ardent spirit, microcosmic salt, and vitriolic acid, the phosphoric acid being probably expelled from its base in a higher state of acidification than it possesses when obtained by suffering phosphorus to deliquesce in the air. An ether is also afforded by the acid of ants, treated in the same method as the acetous acid.

The acid of benzoin does not produce ether by simple digestion with ardent spirit; but when one part of the acid of benzoin is distilled with three of ardent spirit, and half a part of common marine acid, pure spirit comes first over, and afterwards an ethereal combination, part of which floats at the top, and part sinks to the bottom. This is not more volatile than acetous ether, and burns with a bright flame and smoke.

Notwithstanding the great improvements of modern chemistry, we are still in a great measure at a loss respecting the true theory of ethers. It was formerly thought, that the acid merely deprived the spirit of a portion of combined water, which prevented it from exhibiting oleaginous properties. It appears, however, to be ascertained at present, that all ethers contain a portion of that peculiar acid, by whose action the spirit was changed, as may be shewn by suffering them to evaporate, by burning them upon water, or by proper re-agents: and it is also observable, that in some instances the quantity of ether exceeds that of the ardent spirit. Chaptal, in his *Elements of Chemistry*, asserts with confidence, that ether is nothing but a combination of ardent spirit and vital air, and adduces a very curious experiment, wherein he obtains an ethereal liquor by repeated distillations of good alcohol from the red calx of mercury. Valuable, however, as this fact appears to be, it is by no means conclusive in favour of his opinion, which is overthrown, as to its generality, by the remarkable differences in the properties of the several ethers, and the peculiar acids separable from them. Dr. Dollfus, quoted by Hopson*, in his notes to Weigleb's *General System of Chemistry*, infers that the acid made use of, does, by a process analogous to combustion, convert the vegetable acid of the spirit into a coal, while another part of the same first-mentioned acid combines with the disengaged oleaginous part of the spirit, and forms a subtile soap or ether. And this theory is with considerable acuteness modified by Dr. Hopson, who concludes, that the acid converts ardent spirit into ether by the operation of double affinity; that is to say, admitting that ardent spirit consists of the bases of inflammable and fixed air, or the vegetable principle, in combination, as inferred from Mr. Lavoisier's analysis by combustion†; he judges, that the vital air of the acid made use of unites with the vegetable principle, and forms acid of tartar and vinegar, while the basis of

* P. 512.

† Acad. Par. 1781, and 1784.

the same acid combines with the inflammable basis of the ardent, and forms ether which is properly an oil.

ETHIOPS, MARTIAL. Iron in the form of a very subtle powder, and in the first stage of calcination. It was introduced into medicine under this name by the younger Lemery, and is thus made: Very clean iron filings are to be put into a glass vessel, and covered with water to the depth of two or three inches. In this situation they are to be frequently agitated, until a considerable portion has acquired the form of a black powder, easily suspended in the water. By decantation of the turbid water, and subsequent repose, the black powder may be obtained separate, which is afterwards to be dried by heat in a glass retort, and ground fine upon porphyry.

The ethiops appears to be produced by the concurrent action of the air and water: for this last, when pure, acts very little upon iron. It was formerly supposed to possess peculiar advantages as a medicine; but there is no reason to think that the degree of calcination, in which only it differs from the other calces of iron, is of much consequence to the medical exhibition of this metal.

The martial ethiops is in a state so nearly approaching that of the pure metal, that it obeys the magnet, and was used by Dr. Knight, to make artificial loadstones, by kneading it up with linseed oil.

ETHIOPS, MINERAL. A combination of mercury and sulphur. It is black, and may be made either by triturating, in a glass or earthen vessel, two parts of mercury with three of flowers of sulphur, till the mercury has disappeared; or otherwise, by fusing sulphur in an unglazed earthen vessel, taking it from the fire, and mixing an equal weight of mercury by stirring the mass with a spatula till it is cold. It is then to be pounded and sifted.

Mercurial ethiops is said not to differ from cinnabar, except in the proportion of the materials. It seems probable, however, that the mercury may be more calcined in the latter than in the former compound.

Lemery says, that half the materials are lost when the ethiops is made by fire: but it is probable that this must have arisen from something in the management; for the whole loss in the cinnabar manufactory is less than one fortieth part. *See CINNABAR.*

The ethiops mineral has been given in asthma, sciophula, and other diseases arising from obstruction. It is at present little regarded, and may certainly be considered of little efficacy, if attention be paid to the large doses which may be taken of this substance, with little apparent effect on the patient.

EVAPORATION. A chemical operation usually performed by applying heat to any compound substance, in order to dispel the volatile parts. It differs from distillation in its object, which chiefly consists in preserving the more fixed matters, while the volatile substances are dissipated and lost. And the vessels are accordingly different, evaporation being commonly made in open shallow vessels, and distillation in an apparatus nearly closed from the external air.

The degree of heat must be duly regulated in evaporation. When the fixed and more volatile matters do not greatly differ in their tendency to fly off, the heat must be very carefully adjusted: but in other cases this is less necessary.

As evaporation consists in the assumption of the elastic form, its rapidity will be in proportion to the degree of heat and the diminution of the pressure of the atmosphere. A current of air is likewise of service in this process; partly from its absorbing the vapours, by combining with them as they rise, and partly from the

the convenience attending the speedy removal of these vapours when of a noxious or corrosive nature.

EUDIOMETER. An instrument for ascertaining the purity of air, or rather the quantity of vital or truly respirable air contained in any given bulk of elastic fluid. Dr. Priestley's discovery of the great readiness with which nitrous air combines with dephlogisticated or vital air, and by that means becomes precipitated in the form of nitrous acid (see **ACID, NITROUS**; also **AIR, ATMOSPHERICAL**), is the basis upon which almost every instrument of this kind has hitherto been constructed.

Mr. Cavendish, in the *Philosophical Transactions* *, gives his opinion in favour of the eudiometer of the Abbé Fontana, chiefly because the tube in which the mixture is made is long and narrow, and the other parts are so formed and adjusted, that the air rises slowly in one continued column up the tube—advantages which afford time to separate the tube from the rest of the apparatus, and shake it before the airs come quite in contact; by which means the diminution is much greater and more speedy than it would otherwise be.

For instance, if equal measures of common and nitrous air be mixed in this manner, the bulk of the mixture will in general be about one measure: whereas, if the airs be suffered to remain in contact about one fourth of a minute before they are shaken, the bulk of the mixture will be hardly less than one measure and two tenths; and will be very different accordingly as it is suffered to remain, a little more or a little less time, before it is shaken. In like manner the result will be varied, if by any fault in the apparatus the air be suffered to rise in bubbles; because in this case it will not be possible to agitate it soon enough.

The speedy acquisition of the maximum of diminution is another great advantage in the method; and the whole is well explained by Mr. Cavendish, who concludes, that they depend on the presence of the water, which at the very instant of the combination of the airs is by the agitation brought every where into contact with the precipitated nitrous acid, and consequently absorbs it with readiness and facility.

The eudiometer of Mr. Cavendish consists of the following apparatus: **A** (plate II. fig. 2.) is a cylindrical glass vessel, with brass caps at top and bottom; to the upper cap is fixed a brass cock, **B**: the bottom cap is open, but is made to fit close into the brass socket **D d**, and is fixed in it in the same manner as a bayonet is on a musket. The socket **D d** has a small hole in its bottom, and is fastened to the board of the pneumatic tub (fig. 3. pl. I.) by the bended brass **F f G**, in such manner, that **b** the top of the cock is about half an inch under water. Consequently if the vessel **A** be placed in its sockets with any quantity of air in it, and the cock be then opened, the air will run out by the cock, but will do so very slowly, as it can escape no faster than the water can enter by the small hole **E** to supply its place.

Besides this vessel **b**, there are three glass bottles **M** (fig. 3), each with a flat brass cap at bottom to make it stand steady, and a ring at top to suspend it by, and also some measures of different sizes, such as **B** (fig. 4). These are of glass, with a flat brass cap and a wooden handle. In using them they are filled with the air required to be measured, and then set upon a brass knob, **c**, fixed on the shelf

* Vol. lxxiii. p. 107.

of the apparatus below the surface of the water. This knob drives out some of the air, and leaves only the proper quantity.

The author uses two different methods of mixing the airs: the first is, to add the respirable air slowly to the nitrous; and the other to add the nitrous in the same manner to the respirable. He most commonly uses the first. In this method a proper quantity of nitrous air is put into one of the bottles M, by means of one of the measures here described; and a proper quantity of respirable is let into the vessel A, by first filling it with this air, and then setting it on the knob C, as was done by the measure. The vessel A is then fixed in the socket, and the bottle M placed with its mouth over the cock. Then on opening the cock, the air in the vessel A runs slowly in small bubbles into the bottle M, which is kept shaking all the time by moving it backwards and forwards horizontally, while the mouth still remains over the cock.

The errors arising from a greater quantity of water remaining adherent to the inside of the measures and tubes in eudiometers at one time than another, are found to be very considerable. Mr. Cavendish obviates them by ascertaining the diminution of bulk from the weight of water admitted into the vessels. For this purpose he suspends a forked wire from one end of a balance, placed so as to hang over the tub of water, to each end of which fork is fixed a fine copper wire. In trying the experiment, the vessel A, with the respirable air in it, is first weighed by suspending it from one of these copper wires, in such manner as to remain entirely under water. The bottle M, with the proper quantity of nitrous air in it, is then hung on in the same manner to the other wire, and the weight of both together found. The air is then let out of the vessel A into the bottle M, and the weight of both vessels found again, the increase of weight being that of a volume of water equal in magnitude to the air which has disappeared by the combination. Lastly, the bottle M is taken off, and the vessel A weighed by itself, which gives the quantity of respirable air made use of by a similar increase in its weight. Care must be taken in this method that the surfaces of the air in both vessels be nearly or absolutely on the same level, that the pressure of the superincumbent water may be equal on both.

I have given an account of this eudiometer and the method of using it, because in fact it appears to possess the means of greater accuracy than any other. The whole paper is highly deserving of the attention of philosophers.

EUPHORBIIUM. A gummy resin exuding from a large oriental shrub, *Euphorbia officin.* Linn.

It is brought to us immediately from Barbary, in drops of an irregular form; some of which, upon being broken, are found to contain little thorns, small twigs, flowers, and other vegetable matters; others are hollow, without any thing in their cavity; the tears in general are of a pale yellow colour externally, somewhat white within: they easily break betwixt the fingers. Lightly applied to the tongue, they affect it with a very sharp biting taste; and, upon being held for some time in the mouth, prove vehemently acrimonious, inflaming and exulcerating the fauces, &c. Euphorbium is extremely troublesome to pulverize, the finer part of the powder which flies off, affecting the head in a violent manner. The acrimony is so great as to render it absolutely unfit for any internal use. Several correctors have been contrived to abate its virulence, but the best of them are not to be trusted to; and as there seems to be no real occasion for it, unless

unless for some external purposes, we think with Hoffman and others, that it ought to be expunged from the catalogue of internal medicines.

EXCREMENTS. However important the knowledge of the component parts of fecal matter may be, to facilitate our acquaintance with the animal system, it may easily be imagined, that the pursuits of the majority of chemists would be directed to departments of the science which promised effects of a less unpleasant nature. We possess but one set of experiments made on this subject by Homburg at the beginning of the present century. This philosopher, in consequence of alchemical information, instituted a set of operations upon the fecal matter of men fed entirely upon the bread of Gonesse* and Champagne wine. He found, that, when recent, it afforded by distillation to dryness an aqueous, clear, insipid liquor of a disagreeable odour, which contained no volatile alkali; but, by continuing to distil the residue by a graduated fire, he obtained fluid and concrete volatile alkali, a fetid oil, and a coaly residue; substances which this imperfect method of analysis exhibits with every kind of animal substance.

The human fecal matter, by lixiviation in water, filtration, and subsequent evaporation, afforded an oily salt resembling nitre, which was fused on ignited coals, and took fire when heated to a certain degree in closed vessels. The same fecal matter, after it had undergone a complete putrefaction for forty days in the gentle heat of a water bath, afterwards afforded by distillation a colourless oil without smell, which was the thing sought after; but it did not fix mercury, as he had been led to expect.

Imperfect as this examination is, it is rendered still less generally applicable by the peculiar nature of the aliments from which the matter originated. For it cannot be doubted, but that, as the excrements are the residue of the food taken, they will differ according to the nature of that food, as is indeed sufficiently evinced from their more obvious qualities.

EXPANSION. All bodies expand by heat; but the differences are exceedingly great between some bodies and others. Whether this difference may depend upon, or be connected with, any of the other known properties of the several bodies, cannot be inferred from any experiments yet made. Of all substances hitherto examined, it is found that the vegetable fibre varies its dimensions lengthwise the least by change of temperature; for which reason a straight-grained rod of deal wood is found to be much preferable to any other simple substance in the construction of pendulums for clocks. This same object, namely, the construction of pendulums, together with other circumstances relative to geometrical admeasurements, have rendered it of some importance to ascertain the proportional expansions of metals, and some other bodies, by change of temperature. There are two ways of doing this. The first, practised by Musschenbroek, Ellicott, and many others, consists in the application of a train of wheels or levers, which magnify the motion by the increased velocity of the extreme part of the train. The other contrivance, by Ramsden, consists in placing two microscopes above the body whose dimensions are required to be ascertained; and as these instruments are fixed to a bar of cast iron constantly kept at the freezing temperature by surrounding it with melting ice, their distance does not vary from this

* A small town near Paris, where the most excellent bread is made,

cause. The last method, practised by General Roy*, is much preferable to any other hitherto carried into effect; and it is much to be regretted that the substances examined by the General were so few in number. He found that the expansions of the following substances, in each foot of length, by a change of temperature of 180 degrees of Fahrenheit's thermometer, that is to say, from the freezing to the boiling points of water, were as under.

Standard brass scale, length 42.187. It expanded per foot 0.0222646 inch.

English plate brass rod 5 feet long, difficult from its thinness to be kept free from warping, expanded per foot 0.0227136 inch.

English plate brass in form of a trough, perfectly strong, expanded per foot 0.0227386 inch.

Steel rod 5 feet long expanded per foot 0.0137368 inch.

Cast iron prism 5 feet long expanded per foot 0.0133126 inch.

Glass tube 5 feet long expanded per foot 0.0093138 inch.

Solid glass rod 40½ inches long expanded per foot 0.0096944 inch.

The brass scale was supposed to be Hamburgh brass.

The makers of astronomical regulators availed themselves of the difference of expansion of brass and steel to make pendulums, whose centres of oscillation remain at an invariable distance from their respective centres of suspension. Portable time-pieces are likewise made to ascertain the longitude at sea with considerable precision, by forming the rim or circular part of the balance of brass and steel foldered together, the ring of brass being outermost. The effect of two such pieces of metal being foldered together is, that they change their figure by change of temperature. For it may easily be understood, that when a rod of brass is firmly foldered to a rod of steel, and the temperature of both be raised, the greater expansion of the brass will cause that side of the compound bar to be longer than the opposite side which is steel. And this cannot take place without bending of the bar, which accordingly takes place, the brass side becoming convex. A diminution of temperature restores the original figure, and a still greater degree of diminution must of course bend it the contrary way.

The construction of time-pieces is very remotely related to the pursuits of the chemist; but there is no department of science which cannot indicate useful truths to the cultivators of other branches: this ingenious application of the differences of expansion in metals is here mentioned as a hint to the chemist, who may easily apply it in the construction of a thermometer for measuring the degrees of heat by the actual ignition of two metals rivetted, or otherwise fastened together.

EXPRESSION, or PRESSURE. The juices of vegetables, and the fluid parts of other soft substances, are obtained by putting them into a cloth or bag, and exposing it to the action of the press.

EXTRACT. When decoction is carried to that point as to afford a substance either solid or of the consistence of paste, this residual product is called an extract. When chemists speak of extract or extractive matter, they most commonly mean the product of aqueous decoction; but the earlier chemists frequently speak of spirituous extract.

* Philosophical Transactions, vol. lxxv.

F.

FARINA.—*See* BREAD.

FAT. The fat of animals is a substance of the same nature as those oils which are called fat oils in the vegetable kingdom. Its consistence is various in different animals, and in different parts of the same animal. The fat of the human species and of quadrupeds is consistent, and of a white or yellowish colour; the fat of the internal parts being usually firmer than that which is placed among the muscles. It possesses all the characters of vegetable fat oils, though the crude fat of animals appears to contain a considerable quantity of mucilage or jelly peculiar to that kingdom, which may for the most part be washed off by agitation in a large quantity of hot water.

Neumann treated the fat of the goose, the hog, the sheep, and the ox, in a glass retort by a fire gradually raised. He obtained phlegm, an empyreumatic and brownish oil, and a brilliant coal. This analysis led him no farther than to the conclusion, that there is little difference between fats. But modern experiments have shewn that it contains an acid of a peculiar nature, for an account of which see **ACID OF FAT**.

FEATHERS. We do not possess experiments that point out any difference between feathers and the other animal coverings, when chemically considered. The horns, hair, and feathers of animals are more consistent than the skin and muscular parts, and appear to contain less gelatinous matter. Perhaps they may, on due enquiry, be found to contain a large portion of serum. Neumann found that feathers afforded more volatile alkali than hair or wool, but less than silk. Caustic alkali combines with them by boiling.

FELT SPAR. An hard stone of the siliceous class, called likewise Scintillating Spar, Fusible Spar, and Rhombic Quartz. It is generally opaque, white, red, yellow, brown, green, violet, or iridescent; sometimes crystallized in rhombic, cubic, or parallelepipedal forms, and often irregular. Its texture, though close, is lamellated, and it breaks like spar. Its specific gravity is from 2400 to 2600; its hardness sufficient to give fire with the steel, though it is less than that of quartz.

Kirwan assures us that it is more fusible without addition than the fluors, and forms a whitish glass which does not act on the crucibles. Borax and microcosmic salt dissolve it totally in the dry way without effervescence, but it does not easily combine with fixed alkalis. The crystallized sort decrepitates in the fire.

It never constitutes veins or strata, but is either found in loose masses at most two inches long, or mixed with sand or clay, or embodied in other stones, as granites.

One hundred parts of the white contain about 67 of siliceous earth, 14 of argillaceous, 11 of ponderous, and 8 of magnesia.

Mr. Kirwan says, that this is undoubtedly the petuntse made use of by the Saxons in their porcelain manufactories.

The Labrador stone is a beautiful species of this stone, exhibiting a variety of colours

colours according to the position of the eye of the observer, and the direction of the light which falls upon it.

FERMENT. *See* FERMENTATION.

FERMENTATION. This word was formerly used in a very undefined and general sense, to denote every change undergone by organized substances, of which the cause was not apparent; such as chemists are apt to call by the name of spontaneous changes. But it is at present confined almost exclusively to the changes which saccharine matters undergo in certain situations of temperature and moisture. The putrefaction of animal bodies is likewise not unfrequently termed the putrefactive fermentation; though it would be perhaps more useful to confine this word to saccharine matter.

Fermentation has been distinguished into three stages: the vinous or spiritous, the acid or acetous, and the putrid or putrefactive; which are so called from the principal products afforded during each of them respectively. It is ascertained almost beyond a doubt, that the vinous fermentation takes place only in such bodies as contain saccharine juices. In this the most remarkable product is that volatile, light, colourless, inflammable fluid which mixes with water in all proportions, and is called ardent spirit. The acetous fermentation is distinguished by the product known by the name of vinegar, which is the least destructible of the mere vegetable acids. It does not appear, however, that fermentation is absolutely necessary for the production of this acid, which may be had by treating various organized bodies with nitrous acid. In the putrid fermentation these bodies appear to be reduced into very simple principles. Volatile alkali is the product which has been remarked as the chief in this process, and is doubtless produced by the combination of inflammable and phlogisticated air, which fly off in this process. It may also be had in a variety of direct chemical processes.—*See* ALKALI, VOLATILE.

The acetous like the vinous fermentation is confined to vegetable substances; but the putrefactive process is most eminently perceived in animal bodies. These either putrefy immediately without any other previous change, or, if the putrefaction be preceded by either of the other stages, their duration and intensity are insensible. It is considered as an established fact, that the three stages of fermentation always follow each other in the same order in such bodies as are susceptible of them all; the vinous coming first, which is followed by the acetous, and putrefactive processes.

These spontaneous effects are greatly retarded by extreme cold, or by sudden desiccation, or by preservation of the bodies in vessels so well closed as to prevent the escape or absorption of elastic fluid. The two first of these necessarily retard the chemical processes, by depriving the parts of the requisite fluidity; and it may without difficulty be understood, that the changes of combination cannot by any means be completely made, while the communication with the open air, the great receptacle and solvent of volatile matter, and one of the chief agents in the great operations of nature, is cut off.

The three conditions for the due accomplishment of fermentation will therefore be, fluidity, or moisture; moderate heat, or a due temperature; and the access of air. It will of course be modified also by the component parts of the body itself.

As the vinous fermentation has never been found to take place where sugar was not present, it appears the most simple to consider what happens when mere sugar and water in due proportions are exposed to fermentation. If a considerable quantity of water, holding in solution about one-third of its weight of sugar, be exposed to the air, at the temperature of about 70 degrees of Fahrenheit's thermometer, after the addition of a small quantity of yeast, it soon undergoes a remarkable change. In the course of a few hours the fluid becomes turbid and frothy; bubbles of fixed air are disengaged, which rise and break at the surface. This disengagement becomes more and more abundant; mucilage is separated; part of which subsides to the bottom, and part, expanded into froth by the elastic fluid, forms yeast. During the course of several days these effects gradually come to their height, and diminish again; after which they proceed very slowly, but are long before they entirely cease. The fermented liquor has no longer the sweet taste it had before; but becomes brisk and lively, with a pungent spirituous flavour. Its specific gravity is likewise considerably less than before; and when exposed to distillation, it affords a light inflammable spirit miscible with water in all proportions. The quantity of ardent spirit which any fermented liquor will produce, is thought to follow some proportion of the change its specific gravity undergoes in fermentation; but the truth of this has not been clearly ascertained. Wine, cyder, and beer are well-known liquors of this kind.

When it is required to preserve fermented liquors in the state produced by the first stage of fermentation, it is usual to put them into casks before the vinous process is completely ended; and in these closed vessels a change very slowly continues to be made for many months, and perhaps for some years.

But if the fermentative process be suffered to proceed in open vessels, more especially if the temperature be raised to 90 degrees, the acetous fermentation comes on. In this the vital air of the atmosphere is absorbed; and the more speedily in proportion as the surfaces of the liquor are often changed by lading it from one vessel to another. The usual method consists in exposing the fermented liquor to the air in open casks, whose aperture at the bung is covered with a tile to prevent the entrance of the rain. By the absorption of vital air which takes place, the inflammable spirit becomes converted into an acid. If the liquid be then exposed to distillation, pure vinegar comes over instead of ardent spirit.

When the spontaneous decomposition is suffered to proceed beyond the acetous process, the vinegar becomes viscid and foul; air is emitted with an offensive smell; volatile alkali flies off; an earthy sediment is deposited; and the remaining liquid, if any, is mere water. This is the putrefactive process.

Modern discoveries have greatly elucidated the phenomena of fermentation; but much still remains to be accurately determined concerning the processes, the products, and their proportions. It is not clearly ascertained what the yeast or ferment performs in this operation. It seems probable, that the fermentative process in considerable masses would be carried on progressively from the surface downwards; and would, perhaps, be completed in one part before it had perfectly commenced in another, if the yeast, which is already in a state of fermentation, did not cause the process to begin in every part at once. See BREAD, PUTREFACTION, TARTAR, SPIRIT ARDENT, WINE, VINEGAR, VEGETABLE KINGDOM.

FILTRATION. An operation, by means of which the greatest part of a fluid is mechanically separated from such consistent particles as may be merely mixed with it. It does not differ from straining.

An apparatus fitted up for this purpose is called a filter. The form of this is various, according to the intention of the operator. A piece of tow, or wool, or cotton, stuffed into the pipe of a funnel, will prevent the passage of grosser particles, and by that means render the fluid clearer which comes through. Sponge is still more effectual. A stripe of linen rag wetted and hung over the side of a vessel containing a fluid, in such a manner as that one end of the rag may be immersed in the fluid, and the other end may remain without, below the surface, will act as a syphon, and carry over the clearer portion. Linen or woollen stuffs may either be fastened over the mouths of proper vessels, or fixed to a frame, like a sieve, for the purpose of filtering. All these are more commonly used by cooks and apothecaries than by philosophical chemists, who, for the most part, use the paper called cap paper, made up without size.

As the filtration of considerable quantities of fluid could not be effected at once without breaking the filter of paper, it is found requisite to use a linen cloth, upon which the paper is applied and supported.

Precipitates and other pulverulent matters are collected more speedily by filtration than by subsidence. But there are many chemists who disclaim the use of this method, and avail themselves of the latter only, which is certainly more accurate, and liable to no objection where the powders are such as will admit ofedulcoration and drying in the open air.

FIRE. The word heat has been used with so much precision by Doctors Black, Irvine, Crawford, and others, that the word fire seems to have been rendered of little use, except to denote a mass of matter in a state of combustion, which is, indeed, its vulgar acceptation. The term has, however, been used by many eminent writers, to denote what these great philosophers call the matter of heat.—For which see the article **HEAT**.

FISH. It appears from the experiments of Neumann, that fish afford more volatile alkali by destructive distillation than the flesh of land animals does. Lobsters and other shell fish have been thought to contain a disengaged alkali; but this may with justice be doubted.

FIXITY. The property by which bodies resist the action of heat, so as not to rise in vapour. It is the opposite to volatility. The fixity of bodies appears to be merely relative, and depends on the temperature at which they assume the elastic state or form. Such bodies as assume this state at a low temperature will easily rise; whereas those which cannot be so dilated but at an extreme heat, will remain fixed in all ordinary situations. From the analogy of a variety of facts, it does not seem probable that any substances are absolutely fixed.

Fixed bodies are, for the most part, denser than those which are more volatile. The planets nearest the sun are also found to be denser than those which are more remote, and are certainly formed of more fixed materials, as far as our experiments of heat on the solids and fluids of this globe can assure us.

FLAME. Newton and others have considered flame as an ignited vapour, or red hot smoke. This, in a certain sense, may be true, but, no doubt, contains an inaccurate comparison. Simple ignition never exceeds in intensity of light the body by contact of which it was produced. But it appears to be well

ascertained, that flame always consists of volatile inflammable matter in the act of combustion and combination with the vital part of the atmosphere. Many metallic substances are volatilized by heat, and burn with a flame by the contact of the air in this rare state. Sulphur, phosphorus, and some other bases of acids exhibit the same phenomenon. But the flames of organized substances are in general produced by the extrication and accension of inflammable air with more or less of charcoal. When the circumstances are not favourable to the perfect combustion of these products, a portion of the coal passes through the luminous current unburned, and forms smoke. Soot is the condensed matter of smoke.

As the artificial light of lamps and candles is afforded by the flame they exhibit, it seems a matter of considerable importance to society to ascertain how the most luminous flame may be produced with the least consumption of combustible matter. There does not appear to be any danger of error in concluding that the light emitted will be greatest when the matter is completely consumed in the shortest time. It is therefore necessary that a stream of volatilized combustible matter of a proper figure, at a very elevated temperature, should pass into the atmosphere with a certain determinate velocity. If the figure of this stream should not be duly proportioned; that is to say, if it be too thick, its internal parts will not be completely burned for want of contact with the air. If its temperature be below that of ignition, it will not burn when it comes into the open air. And there is a certain velocity at which the quantity of atmospheric air which comes in contact with the vapour will be neither too great nor too small; for too much air will diminish the temperature of the stream of combustible matter so much as very considerably to impede the desired effect, and too little will render the combustion languid.

We have an example of a flame too large in the mouths of the chimneys of furnaces, where the luminous part is merely superficial, or of the thickness of about an inch or two, according to circumstances, and the internal part, though hot, will not set fire to paper passed into it through an iron tube; the same defect of air preventing the combustion of the paper as prevented the interior fluid itself from burning. And in the lamp of Argand we see the advantage of an internal current of air, which renders the combustion perfect by the application of air on both sides of a thin flame. So likewise a small flame is whiter and more luminous than a larger; and a short snuff of a candle giving out less combustible matter in proportion to the circumambient air, the quantity of light becomes increased to eight or ten times what a long snuff would have afforded.

FLINT. A semi-transparent hard stone, of the siliceous order, of a greyish, black, or yellowish colour, well known for its general utility in giving fire with the steel. It is commonly found in nodules, in beds of chalk or sand, and frequently exhibits indications of its having been in a soft state. Some specimens are hollow, and internally lined with siliceous crystals. By long exposure on the surface of the ground, they gradually become white on their upper surface first, and afterwards all over. This whiteness, in process of time, penetrates into the substance of the flint, forming a crust sometimes one-twentieth of an inch thick, which may be scraped with a knife. It has been said that this is a conversion of flint into calcareous earth; but I know of no proof of the fact; and as this white matter does not appear to be affected by nitrous acid, I am inclined to think that the flint is merely shattered by the weather in a manner somewhat analogous

analogous to the effect of ignition and quenching in water, which renders it white and friable.

Weigleb found the common flint to contain 80 parts in the 100 flint, 18 clay, and 2 lime. It is used in making glass and pottery.

A solution of siliceous earth, made by fusing flints with a large proportion of fixed alkali, and dissolving the mass in water, is called liquor of flints.

FLOOR. The lower part of a mine is called the floor, and the upper the roof.

FLOUR. The powder of the gramineous seeds. Its use as food is well known. See **BREAD**.

FLOWERS. A general appellation still retained from the elder chemists, and used to denote all such bodies as have received a pulverulent form by sublimation. Thus we have the flowers of antimony, of arsenic, of benzoin, of sal-ammoniac, of sulphur, of zinc, &c. which may be respectively consulted.

FLOWERS OF VEGETABLES. Dr. Lewis, in his notes on Neumann's Chemistry, gives a cursory account of many experiments made with a view to ascertain how far the colour of vegetable flowers might prove of use to the dyer. He found very few capable of being applied to very valuable purposes. Many of the blue flowers gave out their colour to water, but none that he tried gave a blue tinge to ardent spirit. No preparation offered itself with blue flowers, but the green lake afforded by adding lime water to the aqueous infusion. The red flowers gave, in general, their colour to water, but it was perishable; and his other experiments with these were not more productive of advantage than those upon the blue. Yellow flowers, whether pale or deep, afforded a colour in general durable. Water and ardent spirit both extracted it. Neither acids nor alkalis were found to change its species, though they varied the shade; the acids rendering it paler, and the alkalis deeper. White flowers afforded a green tincture with alkalis; but whether of value or not the Doctor does not say.

FLUIDITY. The state of bodies when their parts are very readily moveable in all directions with respect to each other. Many useful and curious properties arise out of this modification of matter, which form the basis of the mechanical science called hydrostatics, and are of considerable importance in chemistry. But the attention of the chemist is chiefly directed to the state of fluidity as it may affect the component parts of bodies.

A solid body may be converted into a fluid by heat. The less the temperature at which this is effected, the more fusible the body is said to be.

All fluids, not excepting the fixed metals, appear, from various facts, to be disposed to assume the elastic form, and that the more readily the higher the temperature. When a fluid is heated to such a degree as that its elasticity is equal to the pressure of the air, its interior parts rise up with ebullition.

The capacity of a dense fluid for heat is greater than that of the same body when solid, but less than when in the elastic state. If this were not the case, the assumption of the fluid and elastic state would be scarcely at all progressive, but effected in most cases instantly as to sense. See **HEAT**.

The state of dense fluidity appears to be more favourable to chemical combination than either the solid or elastic state. In the solid state, the cohesive attraction prevents the parts from obeying their chemical tendencies, and in the elastic state the repulsion between the parts has in a great measure the same effects. Hence

has been considered, though too hastily, as a chemical axiom, that *corpora non agunt nisi fluida*.

FLUOR. This word has been used to distinguish such bodies as are for the most part fluid in the temperature of the atmosphere. Thus, for example, the fluor acids, the fluor volatile alkali, are terms sometimes used; but in general the writers on chemistry have not adopted this word.

FLUOR SPAR. This spar is found of different colours, white, yellow, green, reddish, purple, brown, or colourless, more or less transparent, and serving as the matrix for the ores it envelops. Its texture is sparry, or irregularly shattered, and its figure, when regular, cubical. Its hardness is not sufficient to give fire with steel. Acids do not effervesce with it, nor dissolve it, unless when decomposition takes place. Heat causes it to decrepitate; but it neither forms lime, plaster, nor the Bolognian phosphorus, by calcination. When it is placed in contact with a body considerably heated, though not ignited, it emits a phosphoric light; but this experiment can scarcely be twice repeated with the same particles of the spar. A strong heat fuses it without addition, when it is found to act powerfully on the crucible, by virtue of its property of rendering argillaceous and other earths more fusible. Its use as a flux in mine works has caused it to be called fluor or flux spar. All the three fluxes used with the blow-pipe dissolve it without effervescence. It consists of lime united to a peculiar acid.—*See ACID OF FLUOR.* The blue fluors derive their colour mostly from iron, but sometimes from cobalt. Most fluors, according to Kirwan, contain a mixture of argillaceous and siliceous earths, and some marine acid.

FLUX. A general term made use of to denote any substance or mixture added to assist the fusion of minerals. In the large way, lime-stone or fusible spar are used as fluxes; but in small assays, the method of the great operations is not always followed, though it would be very frequently of advantage to do so. The fluxes made use of in assays or philosophical experiments consist usually of alkalis, which render the earthy mixtures fusible, by converting them into glass, or else glass itself in powder.

Alkaline fluxes are either the crude flux, the white flux, or the black flux. Crude flux is a mixture of nitre and tartar, which is put into the crucible with the mineral intended to be fused. The detonation of the nitre with the inflammable matter of the tartar is of service in some operations; though generally it is attended with inconvenience on account of the swelling of the materials, which may throw them out of the vessel, if proper care be not taken either to throw in only a little of the mixture at a time, or to provide a large vessel.

White flux is formed by projecting equal parts of a mixture of nitre and tartar, by moderate portions at a time, into an ignited crucible. In the detonation which ensues, the nitrous acid is decomposed, and flies off with the vegetable acid, and the remainder consists of the vegetable alkali in a state of considerable purity. This has been called fixed nitre.

Black flux differs from the preceding, in the proportion of its ingredients. In this the weight of the tartar is double that of the nitre; on which account the combustion is incomplete, and a considerable portion of the acid and tartar is decomposed by the mere heat, and leaves a quantity of coal behind, on which the black colour depends. It is used where metallic ores are intended to be

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reduced,

reduced, and effects this purpose either by supplying the metal with phlogiston, or rather by combining with the vital air of the calx.—*See* CALCINATION.

There is danger of loss in the treatment of sulphureous ores with alkaline fluxes: for, though much or the greatest part of the sulphur may be dissipated by roasting, yet that which remains will form an hepar with the alkali, which is a most powerful solvent of metallic bodies. The advantage of Mr. Morveau's reducing a flux seems to depend on its containing no uncombined alkali. It is made of eight parts of pulverized glass, one of calcined borax, and half a part of powder of charcoal. Care must be taken to use a glass which contains no lead. The white glasses contain in general a large proportion, and the green bottle glasses are not perhaps entirely free from it.

FORGE FURNACE. The forge furnace consists of an hearth, upon which a fire may be made, and urged by the action of a large pair of double bellows, whose nozzle is inserted through a wall or parapet constructed for that purpose. It is useful for applying a considerable heat with great expedition, and is accordingly very much used by blacksmiths and other artificers. The philosophical chemist will find it very useful for fusions, reductions, and most other experiments that require a strong heat, especially if the vessels be very small. Black lead pots, or small furnaces of every desired form, may be placed as occasions require upon the hearth; and the tube of the bellows being inserted into a hole in the bottom of the furnace, it becomes easy to urge the heat to almost any degree required.

Mr. Wedgwood found the heat of a common smith's forge (I suppose without any addition to the fire-place) to be less than that required for the fusion of cast iron, and considerably below that of his small air furnace.

A principal objection to this and every other furnace with bellows, is the labour of working them.

FRITT. The materials of glass are first mixed together, and then exposed to calcination by a degree of heat not sufficient to melt them. The mass is then called fritt. The calcination deprives it of any accidental combustible matter it might have contained, and disposes it to fusion in the melting-pot with less effervescence than would else have taken place.

FRUITS OF VEGETABLES. In Dr. Lewis's examination of the colouring matters of vegetable fruits, he found that the red juices of fruits did not afford a permanent dye by any treatment he used. The dark dull stain of the black cherry proved considerably durable. **SAP GREEN** is prepared from the berries of buckthorn, and **ANNOTTO** is obtained from the pellicles of the seeds of an American tree. See the words.

FULIGINOUS. Vapours which possess the property of smoke, namely opacity, and the disposition to apply themselves to surrounding bodies in the form of a dark-coloured powder.

FULMINATING AND FULMINATION. In a variety of mercurial combinations, it happens, that one or more of the principles assume the elastic state with such rapidity, that the stroke against the displaced air produces a loud noise. This is called fulmination, or much more commonly detonation.

Fulminating gold, and fulminating powder, are the most common substances of this kind, except gunpowder. For the former and latter of these, see the articles
GOLD.

GOLD and GUNPOWDER. The fulminating powder is made by trituring in a warm mortar three parts by weight of nitre, two of mild vegetable alkali, and one of flowers of sulphur. Its effects, when fused in a ladle, and then set on fire, are very great. The whole of the melted fluid explodes with an intolerable noise; and the ladle is commonly disfigured, as if it had received a strong blow downwards. A dram of the powder makes a report as loud as a cannon; but the noise of a few grains, or single pinch taken between the finger and thumb, is very unpleasant in a room. It has very little effect, unless first melted. A mixture of liver of sulphur, with twice its weight of nitre, produces the same explosion, though in less time: whence it appears, that the alkali and sulphur of the former composition form a liver of sulphur; and that the explosion, in all probability, arises from the sudden extrication of hepatic air from the liver of sulphur, and vital air from the nitre, which burn the instant they are formed.

FURNACE. See APPARATUS.

FUSIBILITY. That property by which bodies assume the fluid state. Such bodies as require a low heat for this purpose, are said to be more fusible than others which require a higher temperature to produce the same effect. Bodies vary greatly in their fusibility. No experiments have yet been made to indicate the cause of these differences. The hardness, softness, brittleness, flexibility, malleability, transparency, opacity, and, in a word, all the other obvious qualities, may, for any thing we know, be alike in two bodies, which will nevertheless differ greatly in the temperature of their fusions.

Some chemists have asserted, that fusion is simply a solution in fire, or the matter of heat: but this opinion includes too many yet undecided questions to be hastily adopted. See FLUIDITY.

FUSION. The act of fusing. Also the state of a fused body.

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GALANGAL. The greater galangal is an East Indian knotty root, with several circles on the surface, of a reddish brown colour on the outside, and a yellowish white within, which greatly resembles ginger in its smell, taste, and chemical composition; but as ginger is the most grateful of the two, the galangal is scarcely ever used.

The smaller galangal, which is knotty, and marked with circular striæ like the other, commonly about the size of the little finger, and of a brown colour both externally and internally, is in smell stronger and more agreeable than the large, and in taste more pungent and hot, like pepper. It contains but a small proportion of oil: sixteen ounces afforded scarcely two scruples; though, probably, if considerable quantities were distilled at once, and the distilled water of one operation employed instead of fresh water in the next, the yield upon the pound would be greater. The oil is less agreeable in smell than the galangal itself,

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and wants its pungency, which of consequence remains in the extract. Very little of the oil arises with rectified spirit: the spirit distilled even from a large quantity of the root has scarcely any taste or smell. With regard to the extracts, the watery is rather more pungent than the spiritous; but the former have nothing of the peculiar flavour of the galangal, greatest part of which is retained in the latter. Sixteen ounces yielded with water six ounces, and afterwards with spirit four drams and two scruples: spirit applied at first extracted an ounce and a half from sixteen, and water extracted afterwards five ounces. *Neumann.*

GALBANUM exudes from an umbelliferous plant, with leaves like those of anise, growing in the East Indies, but most plentifully in Syria and Arabia, called by Tournefort, *Oreoselinum Africanum*, *Galbaniferum frutescens*, *anisi folio*. This juice comes over in masses, composed of white, yellowish, brownish yellow, and brown tears, unctuous to the touch, softening betwixt the fingers, of a bitterish, somewhat acrid, disagreeable taste, and a very strong smell, generally full of bits of stalks, leaves, seeds, and other foreign matters.

Galbanum contains more of a resinous than gummy matter: one pound yields with rectified spirit of wine upwards of nine ounces and a half of resinous extract; but the gummy extract obtained by water from the same quantity amounts only to about three ounces. The resin is hard, brittle, insipid, and inodorous: the gummy extract has somewhat of a nauseous relish, but could not be distinguished to be a preparation of galbanum. The whole smell, flavour and specific taste of this juice, reside in an essential oil, which arises in distillation both with water and spirit, and gives a strong impregnation to both: from a pound of galbanum are obtained, by distillation with water, six drams of actual oil, besides what is retained by the water. In this respect galbanum agrees with *asafoetida*, and differs from *ammoniacum*.

The volatility of the active parts of this juice renders the common method of purifying it, by solution, colature, and evaporation, very injurious to it. The smell of the galbanum is dissipated, during the evaporation, over the whole house; and the inspissated matter, whatever menstruum was employed, is found to have lost the distinguishing qualities of the original juice. To prevent as much as possible this inconvenience, the solution should be made in a distilling vessel, and, after filtration, inspissated in the same, so long at least as the liquor which distils has any smell or taste; after which, the galbanum may be reduced to a due consistence, by further evaporation in an open vessel, and the oil which arises in the distillation mixed with it. Galbanum may likewise be purified sufficiently for inferior purposes, as plasters, by exposing it in winter to a strong frost till it grows hard, and then pulverizing and sifting it. The woody, strawy, stony, and other like matters will be retained in the sieve.

Galbanum, distilled by a strong fire without addition, yields, like other resinous bodies, a large portion of empyreumatic oil, amounting to upwards of eight ounces upon sixteen: it is remarkable of the oil of galbanum, that great part of it appears of a blue colour, sometimes of a deep bright blue, sometimes of only a violet blue. The matter on which the blueness depends, appears to be either very volatile or very changeable: it soon escapes or changes in the air, leaving, instead of the blue, a purple colour.

GALENA, or THE BLACK ORE OF LEAD. This, which is the commonest of all lead ores, and is frequently distinguished by the name of potter's lead ore, is of a dark blueish black colour, with a certain degree of metallic lustre. Its weight is about seven or eight times that of water; its figure usually symmetrical, being
either

either cubical, or a variety of that figure; its texture lamellar, and its hardness variable. The component parts of galena are from fifteen to twenty-five sulphur, from sixty to eighty-five lead, and a variable quantity of silver, scarcely ever exceeding two parts in the hundred. Mineralogists assert, that the small grained galena contains the largest portion of silver; but it is not worth the extraction, if it do not contain one pound in three thousand weight. Quartz is accidentally mixed with galena; and it sometimes contains a very small portion of iron. The reduction of galena may be made by pulverization, torrefaction and fusion, with three times its weight of black flux. The lead is obtained in a metallic button at the bottom of the crucible; and its weight, compared with that of the ore, shews its comparative richness.

The humid analysis of this ore is made by boiling the powder in diluted nitrous acid, which takes up the metallic part, and leaves the sulphur, the stony matrix, and calx of iron, undissolved. Digestion in marine acid will separate the iron from the residue; and caustic fixed alkali will dissolve the sulphur. The residuum, weighed before and after the application of the solvents, will shew the proportion of each.

The nitrous solution will contain the lead and silver: this solution may be precipitated by the mineral fixed alkali, and the precipitate washed in cold water, dried and weighed. After weighing, it must again be digested in caustic volatile alkali, which will dissolve and take up only the calx of silver: the residuum being again dried and weighed, gives the proportion of the calx of lead, of which 132 grains are equivalent to 100 in lead in its metallic state; and the difference between the weight of the precipitate, before and after the application of the volatile alkali, gives the quantity of the calx of silver, of which 129 grains are equivalent to 100 of silver in its metallic form. See LEAD.

GALENA, PSEUDO, an ore of zinc, known in the English mine countries by the name of black jack, or mock lead; its principal ingredients are about half its weight zinc, one third sulphur, with iron, lead, siliceous earth, water, and a small portion of arsenic.

GALL OF ANIMALS. This humour is separated in a large viscus of the lower belly, called the liver; it is afterwards deposited in a bladder, or reservoir, called the gall-bladder, from which it is conveyed into the duodenum by a particular channel.

The bile is glutinous, or imperfectly fluid, like oil; of a very bitter taste; a green colour inclining to yellow; and froths by agitation, like the solution of soap.

If it be distilled on the water-bath, it affords a phlegm, which is neither acid nor alkaline, but putrefies. This phlegm, according to the observation of Mr. de Fourcroy, often emits a smell resembling that of musk: bile itself has the same property, according to the general observation of butchers. When the bile has given out all the water it is capable of affording upon the water bath, the residue is a dry extract, which attracts the humidity of the air, is tenacious, pitchy, and soluble in water. By distillation in a retort, it affords ammoniac, an empyreumatic oil, concrete alkali, and inflammable air. The coal is easily incinerated. It contains iron, mild mineral alkali, and phosphorated lime.

All the acids decompose bile, and disengage an oily substance, which rises to the top. The salts afterwards obtained by evaporation have soda for their basis, which shews that the bile is a true animal soap. The oil which is combined
with.

with soda, is analogous to resins, is soluble in spirit of wine, &c. The metallic solutions decompose bile by double affinity, and produce metallic soaps.

Bile unites with oils, and cleans stuffs in the same manner as soap.

Bile is soluble in alcohol, which separates the albuminous principle. It is the last substance which renders bile coagulable by fire and by acids; and it is this likewise which hastens its putrefaction.

The constituent principles of bile are, water, a spiritous rector, a lymphatic substance, a resinous oil, and soda. Mr. Cadet has found a salt in it, which he thought similar to sugar of milk: this salt is probably no other than that which was discovered by Mr. Poulletier.

Bile is therefore a soap, resulting from the combination of soda with a matter of the nature of resins, and lymphatic substance, which renders it susceptible of putrefaction and coagulation. This substance gives the bile the character of animalization, diminishes its acridity, and favours its mixture with the other humours. The saline part renders the bile more fluid and soluble in water; and it is more acrid the more this principle abounds.

The resinous part differs from vegetable resins: 1. Because these do not form soap with fixed alkalis: 2. Because they are more acrid, and more inflammable: 3. Because the animal resin melts at the temperature of forty degrees, and acquires a fluidity similar to that of fat: from which, however, it differs in being soluble in alcohol, in which respect it approaches to spermaceti.

The acids which act upon bile in the first passages decompose it. The greenish yellow colour of the excrements of infants at the breast, arises from a similar decomposition; and it is the resinous part which tinges them. From the action of the bile upon acids, we may deduce the effect of these remedies when the evacuations are putrid, and the degeneration of the bile is septic. The lymph is then coagulated, and the excrements become harder. This shews the reason why the excrements of infants are so frequently clotted.

When the bile remains a long time in the first passages, as, for example, in chronical disorders, it assumes a black colour, becomes thick, acquires the consistency of an unguent, and forms a lining of several lines in thickness in the intestinal canal, according to the observation of Mr. de Fourcroy. When smeared on paper, and dried, it becomes green; diluted with water, it forms a tincture of a yellow green colour, from which a large quantity of black scales is precipitated: with alcohol it likewise forms a black tincture, and deposits that luminated brilliant salt discovered in biliary calculi by Mr. Poulletier de la Salle. This humour, which forms the *atra bilis* of the ancients, is nothing but the bile rendered thick; and in this case the effect of acids, and the danger of irritating substances, may be easily accounted for. This thickening of the bile clogs the viscera of the lower belly, and produces obstructions.

Many disorders are referable to the predominant character of the bile. On this subject, the interesting Memoirs of Mr. de Fourcroy may be consulted, in the collection of the Royal Society of Medicine for the years 1782 and 1783.

When this bile becomes thick in the gall-bladder, it forms the concretions called biliary calculi.

Mr. Poulletier has paid great attention to the analysis of the stones. He has observed that they are soluble in ardent spirits. When the solution is left to itself for a certain time, brilliant and light particles are seen in it, which Mr. Poulletier found only in the human calculi, and which appeared to him to have the greatest analogy with the salt of benzoïn.

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Mr. de Fourcroy has observed, that the discovery of Mr. de la Salle has been confirmed by the Royal Society (of Medicine), which has received several biliary calculi that appeared to be formed by a salt analogous to that which was observed by this chemist. They consist of masses of transparent crystalline plates, similar to mica or talc. The Society of Medicine possesses in its collection a gall-bladder, entirely filled with this saline concretion.

We may, therefore, as Mr. de Fourcroy observes, admit of two kinds of calculi : the one are opaque, and are afforded only by the condensed bile ; the others consist of the crystals we have described. Boerhaave observed long since, that the gall-bladder of oxen, at the end of the winter, was filled with calculi ; but that the fresh pasturage dissipated these concretions.

Soaps have been proposed as solvents for these calculi. The Academy of Dijon has published the success of a mixture of essence of turpentine and ether. Fresh vegetables, which are such sovereign remedies in destroying these concretions, owe their virtue, perhaps, to the circumstance that they develop an acid in the stomach, as we have observed in the treating of the gastric juice.

The use of the bile in the animal œconomy consists, no doubt, in dividing those substances which have undergone a first digestion in the stomach, and in giving efficacy and force to the motions of the intestines. When its flux is interrupted, it abounds in the blood, and the whole body becomes of a yellow tinge.

The bile or gall is an excellent vulnerary, externally applied : internally taken, it is a good stomachic, and one of the best deobstruents the art of medicine possesses. This kind of remedies deserves the preference, as being more analogous to the constitution ; and bile is a proper medicine when the digestion languishes, or the viscera of the lower belly are clogged.

Bile, like other soaps, removes spots of oil, or other greasy matter, from substances to which they are adherent.

GALLS. See ACID OF GALLS.

GALLEY. An oblong reverberatory furnace, in which a row of retorts is placed beside each other, with their necks protruding through lateral openings.

GAMBOGE is a concrete vegetable juice, the produce of two trees, both called by the Indians *caracapulli* (*gambogia gutta* Lin.), and is partly of a gummy and partly of a resinous nature. It is brought to us either in form of orbicular masses, or of cylindrical rolls of various sizes ; and is of a dense, compact and firm texture, and of a beautiful yellow. It is chiefly brought to us from Cambaja, in the East Indies, called also Cambodja, and Cambogia ; and from thence it has obtained its name of *cambadium*, *cambogium*, and *gambogium*.

It is a very rough and strong purge : it operates both by vomit and stool, and both ways with much violence, almost in the instant in which it is swallowed, but yet, as it is said, without griping. The dose is from two to four grains as a cathartic ; from four to eight grains prove emetic and purgative. The roughness of its operation is diminished by giving it in a liquid form sufficiently diluted.

This gum resin is soluble both in water and in ardent spirit. Alkaline solutions possess a deep red colour, and pass the filter. Dr. Lewis informs us, that it gives a beautiful and durable citron yellow stain to marble, whether rubbed in substance on the hot stone, or applied as dragon's blood ; sometimes is in form

of a spiritous tincture. When it is applied on cold marble, the stone is afterwards to be heated to make the colour penetrate.

It is chiefly used as a pigment.

GANGUE. The stones which fill the cavities that form the veins of metals are called the gangue, or matrix of the ore; the rocks that lie over the veins are called the roof; those that lie under them the floor, and by some the hading: the matrix is almost always a finer species of stone than the surrounding rocks, though of the same genus; even the rocks themselves are finer grained as they approach the vein.

There is no matrix peculiarly appropriated to any metal; it has only been remarked, that tin is generally found among stones of the siliceous genus, and lead very frequently among those of the calcareous.

GARNET, a stone, which, when transparent and of a fine colour, is reckoned among gems. Its colour is bluish or yellowish red; its transparency often obscure, unless it be held to a strong light. The natural form of its crystals is various, and seldom regular. Its texture is granular. The specific gravity of the garnet, according to various authors, is from 3,6 to 4,4. Its hardness is nearly the same as that of the emerald, being less hard than the topaz, and more so than rock crystal.

A strong calcining heat does not deprive it of its colour. A very considerable heat is required to fuse it without addition, when it takes the form of a black slag, obedient to the magnet. Mineral alkali does not attack it so powerfully as borax or microcosmic salt.

According to the analysis of Achard, the garnet contains 48,3 of siliceous earth, 30 of clay, 11,6 of lime, and 10 of iron. The opaque garnets scarcely give fire with steel, and afford about 20 per cent. of iron. Bergman informs us, that they contain tin, and even lead, though very rarely.

The garnet is a very common stone, frequently embodied in the masses of compound rocks. The Syrian garnet, which is of a fine red, inclining to purple, and very clear, though less brilliant than the oriental amethyst, is the most esteemed.

GAS. This term was first applied by Van Helmont, to denote the permanently elastic exhalations afforded in chemical processes. Dr. Priestley, whose extensive and successful researches into this department of natural philosophy have, in the space of a few years, produced a revolution in the science of chemistry, uses the word air as the generic term for permanently elastic fluids. Other chemical writers of great reputation have thought fit to revive Van Helmont's term, and confine the word air to the atmospheric fluid. The English philosophers, however, have in general followed Dr. Priestley; and as it seems altogether as simple, to add the word atmospheric, vital, or respirable, to that air which is peculiarly adapted to the maintenance of life and combustion, as to denote it by any single peculiar term not used in the enunciation of other elastic fluids, we have also adopted the same rule. *See AIR.*

GASTRIC JUICE. That humour which is known by the name of the gastric juice, is separated by glands placed between the membranes which line the stomach; and from these it is emitted into the stomach itself.

In order to obtain the gastric juice in a state of purity, the animals intended to furnish it are kept fasting for two days, after which the stomach is extracted. In this manner Spallanzani obtained thirty-seven ounces of this juice out of the two first

first stomachs of a sheep. The same naturalist caused animals to swallow thin tubes of metal, pierced with several holes, into which he had put small sponges, very clean and dry. He caused crows to swallow eight at a time, which were vomited up at the end of three hours and a half. The juice which he obtained was yellow, transparent, salt, bitter, and leaving very little sediment, when the bird was fasting. The gastric juice may likewise be procured by the vomiting which is excited by irritation during fasting. M. Scopoli has observed, that the most fluid part is only thrown up by irritation; and that the thicker part does not quit the stomach, but by the assistance of an emetic. M. Goffe, who had long accustomed himself to swallow the air, which answered the purpose of an emetic with him, has availed himself of this habit to make some experiments with the gastric juice. He suspends his respiration, receives air into his mouth, and pushes it towards the pharinx with his tongue. This air, rarefied in his stomach, produces a convulsive motion, which clears it of its contents. Spallanzani has observed, the eagles spontaneously emit a considerable quantity of gastric juice, when fasting in the morning.

We are indebted to Reaumur, and the Abbé Spallanzani, for very interesting experiments respecting the virtue and effects of the gastric juice in digestion. They caused animals to swallow tubes of metal, perforated in various places, and filled with aliments, to examine their effects. The philosopher of Pavia used purses of thread, and bags of linen and woollen. He himself swallowed small purses filled with flesh boiled or raw, with bread masticated, and also in its original state, &c.; and likewise small cylinders of wood, five lines in length, and three in diameter, pierced with holes, and covered with cloth.

M. Goffe, availing himself of the facility with which he was able to vomit by means of the air, has taken all kinds of food, and examined the changes they had undergone, by returning them after intervals more or less remote from the time of deglutition.

From these various experiments it follows,

1. That the gastric juice reduces the aliments into an uniform magna, even out of the body, and in vitro; and that it acts in the same manner on the stomach after death: which proves that its effect is chemical, and almost independent of vitality.
2. That the gastric juice effects the solution of the aliments included in tubes of metal, and consequently defended from any trituration.
3. That though there is no trituration in membranaceous stomachs, this action powerfully assists the effect of the digestive juices in animals whose stomach is muscular, such as ducks, geese, pigeons, &c. Some of these animals, bred up with sufficient care that they might not swallow stones, have nevertheless broken spheres and tubes of metal, blunted lancets, and rounded pieces of glass, which were introduced into their stomachs. M. Spallanzani has ascertained, that flesh included in spheres sufficiently strong to resist the muscular action, was completely digested.
4. That gastric juice acts by its solvent power, and not as a ferment; because the ordinary and natural digestion is attended with no disengagement of air nor inflation, nor heat, nor, in a word, with any other of the phenomena of fermentation.

M. Scopoli observes very well, that nothing positive or certain can be asserted respecting the nature of the gastric juice. It is sometimes acid, and sometimes insipid. M. Brugnatelli has found in the gastric juice of carnivorous birds, and some others, a disengaged acid, a resin and animal substance, united with a small

quantity of common salt. The gastric juice of ruminating animals contains ammoniac, an extractive animal substance, and common salt. In our time the phosphoric salts have been found disengaged in the gastric juice.

It appears from the observations of Messrs. Spallanzani and Goffe, that the nature of the gastric juice varies according to that of the aliments. This juice is constantly acid when the diet is vegetable. The Abbé Spallanzani affirms, contrary to Messrs. Brugnatelli and Carminati, that birds of prey have never afforded him an acid juice; and he affirms the same of serpents, frogs, fishes, &c.

In order to shew clearly that there is a great difference between the gastric juices of various animals, it is sufficient to observe, that the gastric juice of the kite, the falcon, &c. does not dissolve bread, though it digests flesh meat; and that the gastric juice of the turkey, the duck, &c. has no action upon flesh, but converts the hardest grain into a pulp.

Messrs. Jurine, Toggia, and Carminati, have made the most successful applications of the gastric juice in the treatment of wounds.

GEANTHRAX. *See* PEAT.

GELATINOUS MATTER, or

GELLY, or JELLY, an animal substance, soluble in water, but not in ardent spirit, capable of assuming a well-known elastic or tremulous consistence by cooling when the water is not too abundant, and liquefiable again by increasing its temperature. This last property remarkably distinguishes it from serum and white of egg, which become consistent by heat.

Jellies are very common in our kitchens: they may be extracted from all the parts of animals, by boiling them in water. Hot water dissolves a large quantity of this substance. Acids likewise dissolve them, as do likewise more particularly the alkalis. Jelly which has been extracted without long decoction, possesses most of the characters of vegetable mucilage; but it is seldom obtained without a mixture of serum.

Jellies in a pure state have scarcely any smell or remarkable taste. By distillation they afford an insipid and inodorous phlegm, which easily putrefies. A stronger heat causes them to swell up, become black, and emit a fœtid odour, accompanied with white acrid fumes. An impure volatile alkali, together with empyreumatic oil, then passes over, leaving a spongy coal, not easily burned, and containing common salt and phosphorated lime.

The nitrous acid disengages phlogisticated air from jellies.

The jelly of various animal substances is prepared for the use of sea-faring persons, under the name of portable soup. The whole art of performing this operation consists in boiling the meat, and taking the scum off, as usual, until the soup possesses the requisite flavour. It is then suffered to cool, in order that the fat may be separated. In the next place, it is mixed with five or six whites of eggs, and slightly boiled. This operation serves to clarify the liquid, by the removal of opaque particles, which unite with the white of egg at the time it becomes solid by the heat, and are consequently removed along with it. The liquor is then to be strained through flannel, and evaporated on the water bath to the consistence of a very thick paste; after which it is spread rather thin upon a smooth stone, then cut into cakes, and, lastly, dried in a stove until it becomes brittle. These cakes may be kept four or five years, if defended from moisture. When intended to be used, nothing more is required to be done than to dissolve a sufficient quantity in boiling water, which by that means becomes converted into soup. *See* GLUE.

GEMS. This word is used to denote such stones as are considered by mankind as precious. These are the diamond, the ruby, the sapphire, the topaz, the chrysalite, the beryl, the emerald, the hyacinth, the amethyst, the garnet, the tourmalin, the opal; and to these may be added, rock crystal, the finer flints or pebbles, the cat's eye, the oculus mundi, or hydrophanes, the chalcedony, the moon-stone, the onyx, the cornelian, the sardonix, agates, and the Labrador-stone; for which, consult the several articles respectively.

GILDING. The art of covering the surfaces of bodies with gold. Manufacturers use the term improperly to denote silvering as well as gilding, and likewise the various methods of producing a golden colour without actually using gold.

The real application of gold as a covering may be performed, either by a metallic mixture after the manner of a pigment; or by friction, upon the same principle as black lead and coloured chalks are used; or by the chemical precipitation of gold from mercury, or some other fit solvent; or, lastly, by glueing or fastening extremely thin leaves of gold to the surface intended to be gilded.

The gold prepared for painting is called shell-gold or gold-powder, and may be obtained by amalgamating one part of gold with eight of quicksilver, and afterwards evaporating the latter, which leaves the gold in the form of powder; or otherwise the metal may be reduced to powder by mechanical trituration. For this purpose, gold-leaf must be ground with honey or strong gum-water for a long time; and when the powder is sufficiently fine, the honey or gum may be washed off with water.

For cold gilding by friction, a fine linen rag is steeped in a saturated solution of gold, till it has entirely imbibed the liquor; this rag is then dried over a fire, and afterwards burned to tinder. Now, when any thing is to be gilded, it must be previously well burnished: a piece of cork is then to be dipped, first into a solution of salt in water, and afterwards into the black powder; and the piece, after it is burnished, rubbed with it.

The chemical application of gold to the surface of metals is usually called water-gilding, a term probably at first confined to such processes as demand the use of a solution of gold in aqua regia. If this solution be copiously diluted with ardent spirit, a piece of clean iron will be gilded by being steeped therein. For the method called Grecian gilding, equal parts of sal ammoniac and corrosive sublimate are dissolved in nitrous acid, and a solution of gold is made in this menstruum; upon this the solution is somewhat concentrated, and applied to the surface of silver, which becomes quite black; but, on being exposed to a red heat, it assumes the appearance of gilding.

The method of gilding silver, brass, or copper, by an amalgam, is as follows: Eight parts of mercury, and one of gold, are incorporated together by heating them in a crucible. As soon as the gold is perfectly dissolved, the mixture is poured into cold water, and is then ready for use.

Before the amalgam can be laid upon the surface of the metal, this last is brushed over with dilute aqua fortis, in which it is of advantage that some mercury may have been dissolved. Some artists then wash the metal in fair water, and scour it a little with fine sand, previous to the application of the gold; but others apply it to the metal while still wet with the aqua fortis. But in either case the amalgam must be laid on as uniformly as possible, and spread very evenly with a brass-wire brush, wetted from time to time with fair water. The piece is

then laid upon a grate, over a charcoal fire, or in a small oven or furnace adapted to this purpose. The heat drives off the mercury, and leaves the gold behind. Its defects are then seen, and may be remedied by successive applications of more amalgam, and additional application of heat. The expert artists, however, make these additional applications while the piece remains in the furnace, though the practice is said to be highly noxious on account of the mercurial fumes. After this it is rubbed with gilders wax, which may consist of four ounces of bees wax, one ounce of verdigrise, and one ounce of blue vitriol : then expose it to a red heat, which burns off the wax ; and lastly, the work is cleared with the scratch brush, and burnished, if necessary, with a steel tool. The use of the wax seems to consist merely in covering defects, by the diffusion of a quantity of red calx of copper, which is left behind after the burning.

The gilding of iron by mere heat is performed by cleaning and polishing its surface, and then heating it till it has acquired a blue colour. When this has been done, the first layer of gold leaf is put on, slightly burnished down, and exposed to a gentle fire. It is usual to give three such layers, or four at the most, each consisting of a single leaf for common works, or two for extraordinary ones. The heating is repeated at each layer, and last of all the work is burnished.

Painting with gold upon porcelain or glass is done with the powder of gold, which remains behind after distilling the aqua regia from a solution of that metal. It is laid on with borax and gum water, burned in, and polished. The gilding of glass is commonly effected by covering the part with a solution of borax, and applying gold leaf upon it, which is afterwards fixed by burning.

The gilders of wood and other compositions designed to supply the place of carved work, make use of two methods : the one called oil-gilding, or gilding in oil, because the gold is made to adhere by means of an oily composition ; the other is sometimes called water-gilding, though seldom, but more frequently burnished gold, on account of the burnish it is capable of, which is one of the principal advantages it possesses over the other method.

Gilding in oil is performed by means of a paint sold under the name of gold size. It consists of drying oil (that is to say, linseed oil boiled upon litharge), and mixed with yellow ochre. It is said to improve in its quality by keeping. This is laid upon the work ; and when it has become so dry as to adhere to the fingers without soiling them, the gold leaf is laid on, and pressed down with cotton. This method of gilding is proper for work intended to be exposed to the weather.

The method of gilding in burnished gold consists in covering the work with parchment size and whiting, thinly laid on at five or six different times. This is covered with a yellow size made of Armenian bole, a little wax, and some parchment size ; but in this, as in most other compositions used in the arts, there are variations which depend on the skill or the caprice of the artists. When the size is dry, the gold is applied upon the surface previously wetted with clear water. A certain number of hours after this application, but previous to the perfect hardening of the composition, the gold may be very highly burnished with a tool of agate made for that purpose. This gilding is fit only for work within doors ; for it readily comes off upon being wetted.

The edges of the leaves of books are gilded by applying a composition of one part Armenian bole, and one quarter of a part sugarcandy, ground together with white of eggs. This is burnished while the book remains in the press, and the gold is laid on by means of a little water.

Leather

Leather is gilded either with leaf-brass or silver, but most commonly by the latter, in which case a gold-coloured varnish is laid over the metal. Tin-foil may be used instead of silver-leaf for this less perfect gilding, upon such works as do not possess flexibility.

GINGER, is the produce both of the East and the West Indies. Two sorts of this root are brought to us, one internally white, the other brown: whether they are the roots of different species of the ginger plant, or of one species taken up at different ages, or in different seasons, is not certainly known. This pungent aromatic is of common use as a spice, and is observed not to heat the constitution near so much as might be expected from its strong biting taste. Its pungency resides not in its volatile, but in its fixed parts: the essential oil contains the smell and distinguishing flavour of the ginger, but all the pungency is left behind in the still.

From sixteen ounces of the common brown ginger may be obtained a dram or a little more of oil. The same quantity yielded, with rectified spirit, an ounce and two scruples of resinous extract, containing all the hot biting matter of the root: from the residuum, water extracted a strong mucilage, which had little or no taste, was difficultly reduced to dryness, and weighed, when exsiccated, five drams and a half. Sixteen ounces, treated first with water, gave four ounces of extract, considerably pungent, a portion of the resinous matter being taken up by the water along with the gummy: from the residuum, spirit extracted five scruples four grains of a very pungent resin. The indissoluble earthy matter amounts to near three-fourths of the root, viz. eleven ounces six drams and sixteen grains. Rectified spirit elevates in distillation some of the more subtil parts of the oil, so as to taste a little of the ginger, though not considerably.

The white ginger contains more soluble matter than the brown. From sixteen ounces of this sort were gained five ounces five drams and a scruple of watery, and afterwards three drams twelve grains of spiritous extract. Spirit applied at first, extracted one ounce and three drams wanting a few grains; and water applied afterwards, took up four ounces and a half: so that the indissoluble part does not amount quite to ten ounces on sixteen. The quantity of essential oil is nearly the same as in the brown sort. *Neumann.*

GINSENG. *Panax quinquefolium* Lin. A small root brought from North America, and sometimes from China; an inch or two in length, taper, finely striated, of a whitish or yellowish colour. It has a very sweet taste, accompanied with a slight bitterishness and warmth.

The Chinese are said to have a very extraordinary opinion of the virtues of this root, and to look upon it as an universal restorative in all decays, from age, intemperance, or disease. The great value there set upon it has prevented its being exported from thence into other countries, and its discovery in North America is but of late date; so that among us it has hitherto been very rarely made use of, although, from what can be judged of it from the taste, it seems to deserve some regard, especially as it is now procurable in plenty.

The American ginseng appears opaque and white when broken; and though it produces a good price in the Chinese market, yet it is vastly less valuable than the ginseng of Chinese growth, which is nearly as transparent as horn. This property seems to have been produced by art, perhaps by long-continued and gentle boiling in water.

GIRASOLE, a name given by the Italians to the opal, which is of the flint kind,

kind, and remarkable for the mutability of its colours, according to the various directions of the light which falls on it, and the position of the eye of the observer.

GLACIES MARLÆ. A name given to the clear transparent gypsum, or vitriolated lime. It is seldom used.

GLASS. The vitriform state is that of an incombustible body, which has been fused by a red heat. All substances, therefore, of sufficient fixity to suffer ignition, and sufficient fusibility to be rendered fluid by the greatest temperatures we are capable of producing, may be converted into glass. The metals, though fixed enough to sustain ignition, and fusible under that temperature, are not converted into glass until they have passed through the process of calcination or combustion.

It is probable that all substances which do not rise into the atmosphere by heat, nor combine with it in combustion, are in their own nature vitrifiable, that is to say, fusible; and that the differences between bodies in this respect are merely relative to our power of producing heat. We shall not however insist more fully upon this extended view of the subject, but shall proceed to consider glass as a body more or less transparent, very hard, brittle, fusible in a strong heat, artificially prepared by fire electric, by friction, and scarcely, if at all, affected by the action of air, water, ardent spirit, oil, or the major part of saline substances.

When, or by whom, the art of making glass was first found out, is uncertain: some will have it invented before the flood; but without any proof. Neri traces the antiquity of this art as far back as the time of Job: but Dr. Merret will have it as ancient as either pottery, or the making of bricks; because, that a kiln of bricks can scarce be burnt, or a batch of pottery be made, but some of the bricks and the ware will be at least superficially turned to glass; so that it must have been known at the building of Babel, and as long before as the making of bricks was used. It must have been known consequently among the Egyptians, when the Israelites were employed by them in making bricks. Of this kind, no doubt, was that fossil glass mentioned by Ferrant. Imperat. to be found under ground where great fires had been. The Egyptians indeed boast, that this art was taught them by the great Hermes. Aristophanes, Aristotle, Alexander Aphrodisæus, Lucretius, and John the divine, put us out of all doubt that glass was used in their days.

Most of the glasses made for direct use, consist of an earthy substance called the basis, and a saline or metallic substance called the flux. The basis is usually siliceous earth, the salt an alkali, and the metal lead. But various admixtures of earth and metallic calces are used in the actual practice of the art. None of the acids, except the phosphoric, are sufficiently fixed to withstand the heat required to form the vitreous combination with an earth; and this salt has not yet been afforded cheap enough to be used except in assays by the blow-pipe. The fluxes in glass-making are useful, not only because more fusible than the earthy matter, to which they communicate the same property, but likewise as solvents which combine with it in the dry way, and in some instances produce a compound possessing greater fusibility than belonged to any of the ingredients. *See* CALCAREOUS EARTH, p. 301.

The earthy substances made use of in the composition of glass are, quartzose, sand, flint, gypseous spar, chalk, and the like, either singly or in various proportions; except, however, that the siliceous earth is not to be dispensed with.

The

The saline additions consist either of barilla or soda, common pot-ash, or wood-ashes, and amount to about one-third part of the whole. These substances are purified and pounded with greater or less care, according to the excellence of the glass intended to be produced. If the materials were put into a vessel and exposed to fusion, they would froth and swell much, partly on account of the escape of moisture and other volatile matter, and partly by reason of some elastic fluid which appears to be extricated at the time of the combination of the basis and the flux. Various impurities of an inflammable nature would likewise remain unconsumed in the body of the glass, and injure its colour. To prevent these inconveniences, the composition is kept for the space of four and twenty hours in a furnace of a particular construction, at a degree of heat not sufficient to produce complete fusion, and with access of air. It is repeatedly stirred during this calcination, and becomes at length converted into an imperfect glass called frit. This is put into the melting-pots, and fused by the strong heat of a reverberatory furnace. The fused glass has the property of sticking to an iron rod or tube, by which means it is taken out, either to ascertain a state of perfection, or to blow it into such utensils as may be wanted. The unvitriifiable salts, or such as do not enter into combination with the earth, swim at the top of the vessel, forming the substance called sandiver, or glass gall, which must be skimmed off.

Neri's Art of Glass-Making, and other books, may be consulted for a description of the mechanical part and utensils of this art. In general, the glass is taken out by dipping an iron tube into the pot, and the quantity to be used at once, is regulated by a process somewhat resembling that of the tallow-chandlers; that is to say, the part first dipped out is suffered to cool a little, and serves as the receptacle for more glass to be taken up at a second dip, and so forth until the quantity is sufficient. The lump of glass may be softened at pleasure, by holding it before the mouth of the furnace. The workman renders it hollow, and of a spherical form, by blowing through the tube. This sphere may be converted into a cone, a cylinder, or any other solid, whose transverse section is a circle, by rolling it on a flat plate of iron. It may be stretched in length by swinging the tube in the air, or giving it a vibratory motion like that of a pendulum. The workmen shew great dexterity in heating the glass in the various stages of the manipulation. They do this in such parts as they are desirous of extending; and on other occasions they cool certain parts of their work, by fanning the air against it. The glass, in the ignited state it possesses after it comes out of the pots, is very tough and flexible, may be cut with shears, bended with pincers, pressed into moulds, and wrought in a variety of methods dependent on these properties, of which the artists very dexterously avail themselves.

As far as observation has hitherto directed us, it appears to be a general rule, that the hardness, brittleness, elasticity, and other mechanical properties of congealed bodies, are greatly affected by the degree of rapidity with which they assume the solid state. This, which no doubt is referrible to the property of crystallisation, and its various modes, is remarkably seen in steel and other metals, and seems to obtain in glass. When a drop of glass is suffered to fall into water; it is found to possess the remarkable property of flying into minute pieces, the instant a small part of the tail is broken off. This, which is commonly distinguished by the name of Prince Rupert's drop, is similar to the philosophical phial, which is a small vessel of thick glass suddenly cooled by exposure to the air. It possesses the property of flying in pieces when the smallest piece of flint or angular pebble

is let fall into it. Many explanations have been offered to account for these and other similar appearances, by referring to a supposed mechanism or arrangement of the particles, or sudden confinement of the matter of heat. The immediate cause however appears to be derived from the fact, that the dimensions of bodies suddenly cooled, remain larger than if the refrigeration had been more gradual. Thus the specific gravity of steel hardened by sudden cooling in water is less, and its dimensions consequently greater, than that of the same steel gradually cooled. It is more than probable that an effect of the same nature obtains in glass; so that the dimensions of the external and suddenly cooled surface remain larger than are suited to the accurate envelopment of the interior part, which is less slowly cooled. In most of the metals, the degree of flexibility they possess, must be sufficient to remedy this inaccuracy as it takes place; but in glass, which, though very elastic and flexible, is likewise excessively brittle, the adaptation of the parts, urged different ways by their disposition to retain their respective dimensions, and likewise to remain in contact by virtue of the cohesive attraction, can be maintained only by an elastic yielding of the whole, as far as may be, which will therefore remain in a state of tension. It is not therefore to be wondered at, that a solution of continuity of any part of the surface should destroy this equilibrium of elasticity; and that the sudden action of all the parts at once, of so brittle a material, should destroy the continuity of the whole, instead of producing an equilibrium of any other kind.

Though the facts relating to this disposition of glass too suddenly cooled are numerous and interesting to the philosopher, yet they constitute a serious evil with respect to the uses of this excellent material. The remedy of the glass-maker consists in annealing the several articles, which is done by placing them in a furnace above the furnace of fusion. The glasses are first put into the hottest part of this furnace, and gradually removed to the cooler parts at regular intervals of time. By this means the glass cools very slowly throughout, and is in a great measure free from the defects of glass which has been too hastily cooled.

It is difficult to speak with any precision concerning the materials, proportion, and management necessary to make the different kinds of glass, such as the green glass for bottles, the greenish or blueish glass for windows, the white glass for mirrors, the white flint glass for bottles, and the crystal glass used for the finer wares, called cut glass, not to mention the dense white glass made expressly for optical uses. All these are made of better quality at some manufactories than at others; and it is probable that this superiority of produce is thus confined by the natural disposition for secrecy which prevails among men, whose pecuniary success in a great measure depends on their monopolizing the effects of their own skill. Far be it from me to pretend to consider this proceeding as immoral. On the contrary, I very much doubt whether any species of property can be defended under a title in any respect so strong as that which a man must hold in his own superiority of intellect and exertion. I mean simply to observe in this place, that, from the causes here mentioned, it is impossible to give a minute account of the art. The green glass is made from impure materials; the basis consisting of a ferruginous stone or sand, and the alkali being such as can be the most cheaply purchased. The colour chiefly depends on the iron; and the glass is harder, more durable, and less destructible by acids remaining in it for a long time, the less the quantity of alkali, and consequently the greater the heat. Pit coal is used as fuel in the English glass-houses. It produces a more intense heat than wood.

Chaptal,

Chaptal, in his *Elements of Chemistry*, mentions the successful establishment of a manufactory of opaque bottles of excessive strength and lightness, composed chiefly of basalt; but he relates that the establishment failed, chiefly on account of the quality of the basalt, which did not constantly prove the same, but, becoming in the latter stages of the undertaking more calcareous, produced an article of a perishable nature.

All the white glasses owe their clearness to the purity of the materials. The finest siliceous sand is fused with purified alkali. The calces of lead act as a powerful flux, and are much used in compositions of this nature. They give density, softness, and a disposition to take a brilliant polish.

Optical writers teach us, that the refracting telescope consists of a convex lens, called the object lens, in the focus of which the image of a remote object is formed; and that this image is seen magnified and distinct by a microscope applied to it, which forms the apparatus at the other end of the telescope. It may easily be imagined, that if the focal image be indistinct, or if there be a number of focal images occupying different parts of the field of view of the telescope, the effect will be less perfect, and the magnifying power must be less, in order that the confusion may be at all tolerable. Whenever a ray of white or compounded light is refracted out of its course, by passing into another simple medium of different density from that through which it originally passed, it is found to be separated into its component parts, which produce the sensations of various colours. This separation is made by virtue of the different properties possessed by the several rays of light, by which some are more refracted in like circumstances than others. Thus the blue is more refracted than the green and yellow, and these are more refracted than the red rays. Whence it follows that a pencil of white light, which passed in parallel rays to a wedge or prism of glass, will come out of the prism on the other side, not only refracted in the whole, but differently refracted as to its parts; the red being less turned out of its course than any of the other rays, and the violet being the most deflected of any. And this difference of direction will be greater, the greater the mean refraction. The edges of a convex lens may be considered as wedges of the same nature, with regard to the light, as the prism here mentioned. Such a lens, refracting the red rays less than any other, will form a red image at a certain focal distance. The yellow rays, being somewhat more refracted, will afford a yellow image, at a distance less remote from the lens; and, for similar reasons, there will be formed, at still nearer distances, images of green, blue and violet, with all the intermediate shades of colour. The entire focal image will consist of all these images irregularly combined. It has been discovered, that the quantity of dispersion is greater in some kinds of glass than in others, while the mean refraction or focal length remains the same. Two prisms of such different kinds of glass, producing the same mean refraction towards contrary parts on a ray of light, would not therefore correct the colorific dispersion, though the ray would proceed onward nearly in its original direction. It would be necessary, in order that this dispersion produced by the one glass should be accurately corrected by the other, that the mean refraction should be greatest in that which possessed the least power in dispersing the rays of light; and, in this case, the colourless emergent ray would not proceed in its first direction. To apply this doctrine to telescopes—Suppose a convex lens formed of such glass as afforded very little colorific dispersion of the rays, and a concave lens of such glass as afforded much of this effect: it will follow, that when these

two lenses possess such a figure as that the concave shall destroy the prismatic colours produced by the convex, the excess of mean refraction must be in the latter; and consequently, that the compound glass will act like a convex lens, and produce a real colourless focal image.

The problem of constructing telescopes which shall be truly achromatic, depends, as we have before observed, chiefly on the perfection to which the glasses can be brought. The general facts respecting glasses for this use are, that lead, and probably other metallic calces, increase the dispersive power more than alkalis, and these last more than earthy fluxes; and that an addition of alkali to glasses containing lead, serves greatly to diminish the mean refraction, without much affecting the dispersive power occasioned by the metal. Hence it might seem easy to compose such glass as the theorems of the optician demand; but the practice is by no means so ready. Regular refraction demands that the medium should possess an uniform density throughout, or, in other words, that the parts of the glass should be well combined together. This however is seldom the case, especially in the dense metallic glass. It is found, that the great fusibility of the glass of lead causes it to flow, and occupy the interstices between the particles of the sand before these are melted. So that some very bright and apparently homogeneous glasses exhibit an infinity of small focal images of a candle, when examined by a magnifier, which are produced by rounded particles of sand remaining in every part of the substance. Another fault, still more common, consists in veins of a different density from the rest, partly arising from imperfect fusion, and partly from the density of the glass in the pots being greater the lower its position.

Various have been the attempts to remedy these defects, more especially since the Board of Longitude has offered a considerable premium for this object. We do not, however, possess any ample detail of these unsuccessful experiments. It is generally understood, that it is in vain to endeavour to make this glass in small furnaces, because the heat in these is continually varying, and is either too low for the requisite fluidity, or so high as to extricate bubbles of elastic matter; whereas a steady heat is required for the purpose. Macquer and others have attempted to correct the evil by repeated fusions and pulverization of the glass, and by exposing it to long continued fires; but without success. It is said, that one of the practices in our glass-houses consists in lading the melted matter from one pot to another in the furnace. But this, on account of the heavy duty of excise, and the impolitic manner in which it is levied, cannot be done to any great extent in this country. If the glass be suffered to cool in the pots after a good fusion, its parts take a symmetrical arrangement, of the nature of crystallization, by which the light is acted upon in a manner independent of its figure, which is thought to be a great impediment to its optical use. Mr. Kier, who has had much experience in this branch of chemistry, is disposed to recommend the trial of component parts different from any which have yet been admitted into the common glasses.

Without presuming to speculate in a department of science wherein my experience is much confined, I shall point out a few facts which may be of use to the philosophical operator, and leave the manufacturer to his own trials. It is generally affirmed, that Mr. Dollond made his original experiments, and constructed those excellent three-foot glasses (which at present bear so high a price, and are not to be made) with one single pot of glass made at the glass-house near Wellclose Square, and that none of the same quality has since been made. But the proprietor of that glass-house has assured me, that the original receipts and practice are still followed

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in the making of optical glafs : that the principal opticians always complain of the bad quality of the glafs, but never fail to take the whole quantity he makes at their request; and that when they renew their orders, they always desire it may be exactly the same as the last. From these circumstances I think it probable, 1. That though one pot of glafs may differ from another, yet there may be as good glafs obtained for optical uses now as formerly, if an optician skilled in the theory and practice, like the late Mr. Dollond, were to undertake the task of adapting the curvatures, and selecting the best lenses. 2. That Mr. Dollond's purpose as a tradesman being now answered, by the establishment of an extensive business, he has not the same motives for exertion upon powerful telescopes as actuated his father. 3. That the profits of this trade are greater, and more certain, when many hundreds of cheap perspectives are made by common workmen, than when a few extraordinary telescopes are made by the most excellent artists, superintended by the master himself; and, consequently, it is not the interest of an established house to extend the latter branch. 4. That it is not the interest of a glafs manufacturer, who can gain a large and regular income by making common utensils, to employ his time in costly experiments upon optical glafs, which, if brought to perfection, would afford but a moderate demand, probably no greater than he now experiences : and, therefore, that the improvement of achromatic telescopes is rather to be expected from a man of science, who may be a practical chemist, than from mere tradesmen.

I suspect the opinion to be ill founded, that those kinds of glasses are unfit for optical uses, which are veiny or clouded, or otherwise unpromising. On the contrary, there are reasons to think that the defects of glafs arise from irregularities too minute and numerous to be discerned or discovered in any way, but by the actual proof of constructing a telescope. There are good glasses which abound with the larger veins; and I possess two achromatic lenses, each of thirty inches focus, whose obvious qualities, and excellence as object glasses, differ very much, and in opposite respects. They are each composed of a convex of crown-glass applied to a concave of flint. The one was constructed for the tube of an astronomical quadrant. It produces no colour, has no aberration from figure, and, when the eye is placed in its focus so as to receive the pencil of light from a fixed star, the whole aperture is uniformly covered with light. The other glass, though perfectly similar, was made for a pocket perspective. It produces scarcely any colour, has considerable aberration from figure, and, when the eye placed in its focus receives the light of a fixed star, the whole aperture is covered with light of an irregular, curdled, or clouded appearance. I have no doubt but the former glass was applied to the superior, and the latter to the inferior use, from their obvious qualities : but when they are examined by the true test of optical excellence, the application of a large magnifying power, the former proves dark and indistinct, while the latter exhibits the object bright and well defined, and is on the whole an excellent lens.

Mr. Reaumur was the first who made any direct experiments upon the conversion of glafs into porcelain, which takes place by the evaporation or absorption of its alkali, during the continuance of a degree of heat less than is sufficient to melt it. Saline glasses are the best for this purpose; and the less salt they contain, the more readily they are converted. Instances of this effect may be observed among the rubbish of brick-kilns, where pieces of green bottles are not unfrequently subjected by accident to the requisite heat; but the direct process is as follows :

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A vessel of green glass is to be filled up to the top with a mixture of white sand and gypsum, and then set in a large crucible upon a quantity of the same mixture, with which the glass vessels must also be surrounded and covered over, and the whole pressed down rather hard. The crucible is then to be covered with a lid, the junctures well luted, and put into a potter's kiln, where it must remain during the whole time that the pottery is baking; after which, the glass vessel will be found transformed into a milk-white porcelain. The glass, on fracture, appears fibrous, as if it were composed merely of silken threads laid by the side of each other: it has also quite lost the smooth and shining appearance of glass, is very hard, and emits sparks of fire when struck with steel, though not so briskly as real porcelain. Lewis observed, that the above-mentioned materials have not exclusively this effect upon glass; but that powdered charcoal, foot, tobacco-pipe clay, and bone-ashes, produce the same change. It is remarkable, that the surrounding sand becomes in some measure agglutinated by this process, which, if continued for a sufficient length of time, entirely destroys the texture of the glass, and renders it pulverulent.

For the other properties and circumstances relative to glass, see **ENAMEL**, **POTTERY**, and the several metallic substances.

GLAUBER'S SALT. The combination of vitriolic acid and mineral alkali.

It contains 15 parts alkali, 27 acid, and 58 water, according to Bergman. See **ACID VITRIOLIC**.

GLIMMER. A name occasionally applied to micaceous earths.

GLUTEN, VEGETABLE. If wheat flower be made into a paste, and washed in a large quantity of water, it is separated into three distinct substances; a mucilaginous saccharine matter, which is readily dissolved in the liquor, and may be separated from it by evaporation; starch, which is suspended in the fluid, and subsides to the bottom by repose; and gluten, which remains in the hand, and is tenacious, very ductile, somewhat elastic, and of a brown grey colour. The first of these substances does not essentially differ from other saccharine mucilages. The second, namely the starch, forms a gluey fluid by boiling in water, though it is scarcely, if at all, acted upon by that fluid when cold. Its habitudes and products with the fire, or with nitrous acid, are nearly the same as those of gum and of sugar. It appears to be as much more remote from the saline state than gum, as gum is more remote from that state than sugar.

The vegetable gluten, though it existed, before the washing, in the pulverulent form, and has acquired its tenacity and adhesive qualities from the water it has imbibed, is nevertheless totally insoluble in that fluid. It has scarcely any taste. When dry, it is semi-transparent, and resembles glue in its colour and appearance. If it be drawn out thin, when first obtained, it may be dried by exposure to the air; but if it be exposed to warmth and moisture while wet, it putrifies like an animal substance. The dried gluten applied to the flame of a candle, crackles, swells, and burns, exactly like a feather or piece of horn. It affords the same products by destructive distillation as animal matters do: is not soluble in ardent spirit, oils, or ether; and is acted upon by acids and alkalis, when heated. See **BREAD**.

GLUE. An inspissated jelly made from the parings of hides and other offals, by boiling them in water, straining through a wicker basket, suffering the impurities to subside, and then boiling it a second time. In this state it is poured into flat frames or moulds; then cut into square pieces when congealed, and afterwards dried in a coarse net. It is said to improve by age; and that glue is reckoned

reckoned the best which swells considerably without melting by three or four days infusion in cold water, and recovers its former dimensions and properties by drying. See JELLY.

GNEIS. The Saxon name of a rock, consisting of mica, lapis ollaris, and quartz.

GOLD is a yellow metal, of much greater specific gravity than any other body in nature, except platina. It is soft, very tough, ductile, and malleable; unalterable and fixed, whether exposed to the atmosphere, or to the strongest heat of furnaces. The most powerful burning mirrors are said to have volatilized it; and it has been driven up in fumes, in the metallic state, by flame urged upon it by a steam of dephlogisticated air. The electric shock converts it into a purple calx, as may be seen by transmitting that commotion through gold leaf between two plates of glass; or by causing the explosive spark of three or more square feet of coated glass to fall upon a gilded surface. A strong heat is required to melt it, which does not happen till after ignition. Its colour, when melted, is of a bluish green; and the same colour is exhibited by light transmitted through gold leaf.

The limits of the ductility and malleability of gold are not known, and its tenacity exceeds that of any other metal. A gold wire, of one tenth of an inch diameter, requires 500lb. weight to break it.

The method of extending gold used by the gold-beaters, consists in hammering a number of thin-rolled plates between skins or animal membranes. By the weight and measure of the best wrought gold-leaf, it is found that one grain is made to cover $56\frac{1}{2}$ square inches; and from the specific gravity of the metal, together with this admeasurement, it follows, that the leaf itself is $\frac{1}{254000}$ part of an inch thick. This, however, is not the limit of the malleability of gold; for the gold-beaters find it necessary to add three grains of copper in the ounce to harden the gold, which otherwise would pass round the irregularities of the newest skins, and not over them; and in using the old skins, which are not so perfect and smooth, they proceed so far as to add twelve grains. The wire which is used by the lace-makers is drawn from an ingot of silver, previously gilded. In this way, from the known diameter of the wire, or breadth when flattened, and its length, together with the quantity of gold used, it is found, by computation, that the covering of gold is only $\frac{1}{11}$ part of the thickness of gold-leaf, though it still is so perfect as to exhibit no cracks when viewed by a microscope.

No acid acts readily upon gold but aqua regia and the dephlogisticated marine acid. The vitriolic acid, distilled from manganese, has some action upon it; as have likewise the pale nitrous acid, and the phosphoric acid when boiling.

The small degree of concentration which the dephlogisticated marine acid is susceptible of, and the imperfect action of the latter acids, render aqua regia the most convenient solvent for this metal.

When gold is immersed in aqua regia, an effervescence takes place with the escape of air, which has not been examined; the solution tinges animal matters of a deep purple, and corrodes them. By careful evaporation, fine crystals of a topaz colour are obtained. The gold is precipitated from its solvent by a great number of substances. Lime and magnesia precipitate it in the form of a yellowish powder. Alkalis exhibit the same appearance; but an excess of alkali redissolves the precipitate. The precipitate of gold obtained from aqua regia by the addition of a fixed alkali, appears to be a true calx, and is soluble in the vitriolic, nitrous,

and marine acids; from which, however, it separates by standing, or by evaporation of the acids. The nut-gall precipitates gold of a reddish colour, very soluble on the nitrous acid, to which it communicates a fine blue colour.

The volatile alkali precipitates the solution of gold much more readily than fixed alkalis. This precipitate, which is of a brown, yellow, or orange colour, possesses the property of detonating with a very considerable noise, when gently heated. It is known by the name of fulminating gold. The presence of volatile alkali is necessary to give the fulminating property to the precipitate of gold; and it will be produced by precipitating it with fixed alkali from an aqua regia previously made by adding sal ammoniac to nitrous acid; or by precipitating the gold from pure aqua regia, by means of sal ammoniac, instead of the volatile alkali alone. The fulminating gold weighs one-fourth more than the gold made use of. A considerable degree of precaution is necessary in preparing this substance. It ought not to be dried but in the open air, at a distance from a fire, because a very gentle heat may cause it to explode. Several fatal accidents have arisen from its explosion, in consequence of the friction of ground stoppers in bottles containing this substance, of which a small portion remained in the neck.

Fulminating gold, when exposed by Berthollet to a very gentle heat in a copper tube, with the pneumatical apparatus of mercury, was deprived of its fulminating quality, and converted into a calx at the same time that alkaline air was disengaged. From this dangerous experiment it is ascertained, that fulminating gold consists of calx of gold combined with the volatile alkali. The same eminent philosopher caused fulminating gold to explode in copper vessels. Phlogificated air was disengaged, a few drops of water appeared, and the gold was reduced to the metallic form. In this experiment he infers, that the volatile alkali was decomposed; that the phlogificated air, suddenly assuming the elastic state, caused the explosion, while the vital air of the calx united with the inflammable air of the alkali, and formed the water.

This satisfactory theory was still further confirmed by the decomposition of fulminating gold, which takes place in consequence of the action of the concentrated vitriolic acid, of melted sulphur, fat oils, and ether; all which deprived it of its fulminating quality, by combining with its volatile alkali.

Liver of sulphur precipitates gold from its solvent; the alkali uniting with the acid, and the gold falling down combined with the sulphur; of which, however, it may be deprived by moderate heat.

Most metallic substances precipitate gold from aqua regia: lead, iron, and silver, precipitate it of a deep and dull purple colour; copper and iron throw it down in its metallic state; bismuth, zinc, and mercury, likewise precipitate it. A plate of tin, immersed in a solution of gold, affords a purple powder, called the purple powder of Cassius, which is used to paint in enamel. There are various methods of managing this process. That described by Macquer consists in dissolving tin by very small portions at a time, without heat, in an aqua regia composed of two parts of nitrous and one of marine acid, previously weakened with water equal in weight to both the acids. The first small portion of tin must be suffered to be entirely dissolved before a second is added. This addition must be continued till the acid has acquired a yellow colour, and scarcely acts at all upon the tin last added.

On the other hand, the purest gold must be dissolved in an aqua regia composed

posed of three parts of nitrous, and one of marine acid. This solution may be made, as expeditiously as the operator chooses, by the assistance of the heat of a sand bath.

The solution of tin must then be largely diluted, as for example, with one hundred parts of distilled water; and a small quantity of this may then be assayed, by separating it into two parts, and diluting one of the parts still farther. Upon trial of both, by letting fall a drop of the solution of gold into each, it will be seen which affords the most beautiful purple precipitate. The whole of the solution of tin must accordingly be altered, if necessary, by adding more water. Pour into this solution, in a large glass or earthen vessel, nearly half as much of the solution of gold as it contains of solution of tin, stirring the mixture with a glass stick. In a short time the liquor will become of a beautiful red colour, which will gradually disappear on the subsidence of the precipitate. By adding a small quantity of the solution of tin, it will be seen whether the whole of the gold is precipitated. The clear liquor must then be decanted, and the precipitate washed. It consists of the calces of gold and tin in combination, and is the only known substance which has the property of communicating a purple colour to glass.

The difficulties attending the preparation of this article appear to depend on the state of the tin. If the solution of this metal be made with heat and rapidity, it becomes too much calcined to adhere to the acid, or to precipitate the gold; and the combination of the two metals, which falls down, varies in colour according as this term is approached. These are the chief circumstances; but there is no doubt but that a complete examination of the process would indicate others worthy of notice.

Ether, naphtha, and essential oils, take gold from its solvent, and form liquors which have been called potable gold. The gold which is precipitated by evaporation of these fluids, or by the addition of martial vitriol to the solution of gold, is of the utmost purity.

In the dry way, gold resists the action of neutral salts, more especially nitre, which deslagrates with the imperfect metals. Nitre, however, does not afford an expeditious way of purifying gold, because this metal in some measure protects and covers the alloys from its action. It is remarked, that borax, used as a flux with gold, renders it paler; and that this alteration of colour disappears by the addition of nitre or common salt. As the acid of borax forms a compound with gold, which falls to the bottom when this acid is added to the metal in solution, it is probable that the paleness produced by borax may arise from the combination of a small portion of its acid with the gold, which might be driven off by a continuance of the heat, and united by stronger affinity with the alkali of the nitre, or of the common salt, in proportion as their acids are dissipated by heat.

Earths and alkalis do not act on gold in the dry way. Sulphur, which combines with most metals, has no effect on this. A process, called dry parting, is grounded on this property; and is more especially used in separating silver from gold, when the quantity of this latter metal is too small to answer the charges of dissolving the larger mass of silver in nitrous acid. For this purpose, the mixed metal is fused, and flowers of sulphur thrown on its surface. This combines with the silver in the form of a black scoria, while the gold remains at the bottom in its metallic state. The operation of dry parting does not leave the gold in a state
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of purity; because the last portions of silver are defended from the action of the sulphur. But when the quantity of silver is thus diminished, the operation of parting, with aqua fortis, or nitrous acid, may be advantageously used.

Liver of sulphur dissolves gold in the dry way. Equal parts of sulphur and vegetable alkali are hastily fused with one-fourth of a part of gold-leaf. This combination is soluble in water, with which it forms a yellowish green solution. By the addition of an acid, the gold is thrown down in combination with the sulphur, of which it may be deprived by heat.

Most metals unite with gold by fusion. With silver it forms a compound, which is paler in proportion to the quantity of silver added. It is remarkable that a certain proportion, for example a fifth part, renders it greenish. From this circumstance, as well as from that of a considerable proportion of these metals separating from each other by fusion, in consequence of their different specific gravities, when their proportions do not greatly differ, it should seem that their union is little more than a mere mixture without combination: for, as gold-leaf transmits the green rays of light, it will easily follow, that particles of silver, enveloped in particles of gold, will reflect a green, instead of a white light.

A strong heat is necessary to combine platina with gold: it greatly alters the colour of the gold, if its weight exceed the forty-seventh part of the mass. It does not much affect the ductility. The Spanish ministry has prohibited the exportation of platina from America, lest it should be used in adulterating gold; but this does not appear to be a danger which need be feared, as chemistry has long been in possession of several simple and expeditious methods of detecting this fraud, which besides is evident to the sight when the quantity of debasement is considerable. It may be questioned likewise, whether the value of platina would not soon equal that of gold, if its properties and uses were better known in society.

Mercury is strongly disposed to unite with gold, in all proportions with which it forms an amalgam: this, like other amalgams, is softer the larger the proportion of mercury. It softens and liquifies by heat, and crystallizes by cooling.

Lead unites with gold, and considerably impairs its ductility. Copper renders gold less ductile, harder, more fusible, and of a deeper colour. This is the usual addition in coin, and other articles used in society. Tin renders it brittle in proportion to its quantity; but it is a common error of chemical writers to say, that the slightest addition is sufficient for this purpose. With iron it forms a grey mixture, which obeys the magnet. This metal is very hard, and is said to be much superior to steel for the fabrication of cutting instruments. Bismuth renders gold white and brittle; as do likewise nickel, arsenick, and antimony. Zinc produces the same effect; and, when equal in weight to the gold, a metal of a fine grain is produced, which is said to be well adapted to form the mirrors of reflecting telescopes, on account of the fine polish it is susceptible of, and its not being subject to tarnish. The alloys of gold with the regulus of manganese, or molybdena, are not known. It could not be mixed with regulus of wolfram, on account of the infusibility of this last substance.

Gold is found mostly in the metallic state, though generally alloyed with silver, copper, iron, or all three. It is found either in separate lumps, or visible grains, among the sands of rivers in many parts of Europe and elsewhere. The quantity is for the most part insufficient to pay the cost of separating it; but it is thought to be more universally diffused in sands and earths than any other metal, except iron.

iron. The greatest quantity of gold is imported into Europe from South America. Some is brought from the East Indian islands and China, and some from the coast of Africa. The principal gold mines in Europe are those of Hungary. Some sands afford gold by simple washing; the heavy metallic particles subsiding soonest: but when it is bedded in earths or stones, these substances are pounded, and boiled with one-tenth of their weight of mercury together with water. The mercury, after a certain time, absorbs the gold, and may be separated by pressure through leathern bags, and subsequent distillation. Or otherwise, if the sand be heated red hot, and quenched in water several times, for the purpose of cracking and dividing it, and the whole be then melted into glass, with twice its weight of the calx of lead called litharge, and charcoal powder be then added, the lead will be revived in the metallic state, and will carry the gold along with it. By exposure to a proper degree of heat, with access of air, the lead may again be converted into litharge, and the gold will be left pure. This last operation is, in fact, a method of assaying sands which contain gold, rather than of obtaining it from them in the large way.

Gold is also found in certain martial pyrites in Sweden and elsewhere; from which it may be extracted by torrefaction or burning of the sulphur, and subsequent digestion in aqua regia.

To obtain gold in a state of purity, or to ascertain the quantity of alloy it may contain, it is exposed to a strong heat, together with lead, in a porous crucible. This operation is called cupellation, and is performed as follows:—The precious metal is put, together with a due proportion of lead, into a shallow crucible made of burned bones, called a cupel; and the fusion of the metals is effected by exposing them to a considerable heat in a muffle, or small earthen oven, fixed in the midst of a furnace. The lead continually vitrifies, or becomes converted into a glassy calx, which dissolves all the imperfect metals. This fluid glass, with its contents, soaks into the cupel, and leaves the precious metal in a state of purity. During the cupellation, the scoriae, running down on all sides of the metallic mass, produce an appearance called circulation, by which the operator judges whether the process is going on well. When this metal is nearly pure, certain prismatic colours flash suddenly across the surface of the globulæ, which soon afterwards appears very brilliant and clean: this is called the brightening, and shews that the separation is ended.

After gold has passed the cupel, it may still contain either of the other perfect metals, platina or silver. The former is seldom suspected; the latter is separated by the operations called quartation and parting. Quartation consists in adding three parts of silver to the supposed gold, and fusing them together, by which means the gold becomes one-fourth of the mass only. The intention of this is to separate the particles of gold from each other, so that they may not cover and defend the silver from the action of the pure nitrous acid which is to be used in the process of parting. Parting consists in exposing the mass, previously hammered or rolled out thin, to the action of boiling aqua fortis of a due strength. If the acid be not too concentrated, it dissolves the silver, and leaves the gold in a porous mass of the original form; but if too strong, the gold is in a powdery form, which may be washed and dried. The weight of the original metal before cupellation, and after the subsequent operations, serve to ascertain the degree of fineness of the ingot, or ore, of which it was a part.

The quantity of alloy is never considered as part of the value of metals which

contain either gold or silver. In estimating or expressing the fineness of gold, the whole mass spoken of is supposed to weigh twenty-four carats of twelve grains each, either real or merely proportional, like the assayers weights; and the pure gold is called fine. Thus, if gold be said to be twenty-three carats fine, it is to be understood that, in a mass weighing twenty-four carats, the quantity of pure gold amounts to twenty-three carats.

In such small works as cannot be assayed by scraping off a part, and cupelling it, the assayers endeavour to ascertain its quality or fineness by the touch. This is a method of comparing the colour and other properties of a minute portion of the metal, with those of certain small bars whose composition is known. These bars are called touch-needles; and they are rubbed upon the black basalt, which, for that reason, is called the touchstone. Black flint, or pottery, will serve the same purpose. Sets of golden needles may consist of pure gold; pure gold $23\frac{1}{2}$ carats with half a carat silver; 23 carats gold with one carat silver; $22\frac{1}{2}$ carats gold with $1\frac{1}{2}$ carat silver, and so forth, till the silver amounts to four carats, after which, the additions may proceed by whole carats. Other needles may be made in the same manner, with copper instead of silver; and other sets may have the addition, consisting either of equal parts silver and copper, or such proportions as the occasions of business require.

In foreign countries, where trinkets and small work are required to be submitted to the assay of the touch, a variety of needles are necessary; but they are not much used in England. They afford, however, a degree of information, which is more considerable than might at first be expected. The attentive assayer not only compares the colour of the stroke made upon the touchstone by the metal under examination, with that produced by his needle, but will likewise attend to the sensation of roughness, dryness, smoothness, or greasiness, which the texture of the rubbed metal excites, when abraded by the stone. When two strokes, perfectly alike in colour, are made upon the stone, he may then wet them with aqua fortis, which will affect them very differently, if they be not similar compositions; or the stone itself may be made red hot by the fire, or by the blow-pipe, if thin black pottery be used, in which case the phenomena of calcination will differ according to the nature and quantity of the alloy.

Gold ores may be assayed in the moist way by pounding them very fine, weighing a determinate portion, and attempting their solution in nitrous acid, which will dissolve the matrix if it consist of calcareous earth; or if it be selenite, the powder may be digested in aqua regia as long as any metallic substance is taken up; after which the gold may be precipitated by an addition of vitriol of iron, which will cause it to fall down in the metallic state.

The principal use of gold is, as the medium of exchange in coin, for which it has been chosen to occupy the first place, on account of its scarcity, its great weight, and its not being subject to tarnish. The gold coins of Great Britain contain eleven parts of gold, and one of copper.

Gold is likewise used in gilding; for which purpose, as we have already shewn, it is mechanically divided into leaves of extreme thinness. These are stuck upon wood, previously smeared with adhesive oil, or animal glue called size. The process called water-gilding, which is usually applied to copper or brass, is performed by immersing the clean copper into a diluted solution of mercury. The copper is corroded by the acid, which at the same time deposits a thin coating of mercury. This coating, after the piece is washed, facilitates the adhesion of an amalgam of gold, which is then to be rubbed upon it. The mercury is afterwards volatilized

by heat; and the work is finished by burning gilding wax upon it, which is a composition of red bole, verdigrease, alum, and bees-wax. The intention of this last application appears to be that of concealing the defects of the gilding.

There is another method of gilding, which is performed by steeping linen rags in a solution of gold. These are afterwards dried and burned to ashes, which contain gold in a very divided state. Nothing more is necessary than to moisten the end of a cork, and dip it in this burned matter, together with a little wood ashes, and rub it upon the face of the silver intended to be gilded. By this means the gold easily adheres.

The other uses of gold, in laces, &c. are sufficiently known.

GRANITE, a compound rock, consisting of quartz, felspar, and mica, and occasionally hornblende, steatites, garnet, or basaltes. It is seen among the paving stones of London, consisting of quartz of a white colour, a reddish felspar, and black or violet shoerl. The parts of granite are so well adapted to each other, that Mr. de Saussure concludes it to have been the product of confused crystallisation.

The granite is called moorstone in English. The proportion and size of its component parts are extremely variable, as well as their colour. The quartz, felspar, and mica, constitute the hardest sort of granite, the most anciently known. That into which the shoerl enters is more subject to decomposition. The granite never has any particular texture or regular form, but consists of enormous shapeless masses, of great hardness.

In the finer granites, the quartz is transparent; in others, generally white or grey, violet or brown. The felspar, white, yellow, red, green, or black, is generally the most copious ingredient. The mica is also grey, brown, yellow, green, red, violet, or black, and is commonly least copious. The shoerl is generally black, and abounds in the granites that contain it.

Hence the colour of granites chiefly depends on that of the spar or shoerl. The red granites consist commonly of white quartz, red felspar, and grey mica. The grey of white quartz, grey or violet felspar, and black mica. The black commonly contain shoerl instead of felspar; and the green commonly contain green quartz.

If granite be exposed to the flame, urged by a blow-pipe, its different concretions separate from each other. In a crucible, Mr. Gerhard found the felspar of a piece of granite melted into a transparent glass; under it the mica lay in the form of a black slag, and the quartz remained unaltered. But when all three were powdered and mixed, it melted somewhat better; yet still the quartz may be distinguished by the help of a lens. This well explains why small white grains are frequently found in lavas. The experiments of Messrs. d'Arcet and Saussure perfectly coincide on this subject.

The mixture of mica prevents the flex or quartz from cracking or splitting; and hence its infusibility and advantageous use in furnaces.

The granitone, mentioned by Ferber, in his Letters from Italy, is a stone composed of felspar and mica. A substance of this kind, which moulders by being long exposed to the air, is found in Finland: it is said to contain sometimes talc-petre, and sometimes common salt. It is there called raparkivi. Wallerius describes eighteen species of granites, besides many other granatic stones, on which the curious reader may consult his Mineralogic System of the edition in 1773.

GRANULATION. The method of dividing metallic substances into grains

or small particles, in order to facilitate their combination with other substances, and sometimes for the purpose of readily subdividing them by weight.

As the entire metals cannot be pulverised, because not sufficiently brittle, and as the mechanical subdivision of their parts is attended with considerable labour and difficulty, recourse is generally had to fusion; and the subdivision is made at the instant of congelation. This is done either by pouring the melted metal into water, or by agitating it in a box until the moment of congelation, at which instant the whole becomes converted into a powder. These different processes are preferable the one to the other, according to the nature of the metallic substance. Thus gold, silver, copper, or iron, cannot be granulated by agitation, not only because the great heat required for their fusion would be productive of inconvenience, but likewise because they possess a great degree of tenacity when heated almost to melting. Lead, tin, and brass, on the contrary, are very brittle when heated, and are therefore best granulated in this way.

Various contrivances are used to prevent danger and insure success in the several manufactories that require granulation. Copper is granulated for making brass, by pouring it through a perforated ladle into a covered vessel of water with a moveable false bottom. A compound metal, consisting chiefly of lead, is poured into water through a perforated vessel of another kind, for making small shot, in which the height above the surface of the fluid is said to require particular adjustment. But in a new manufactory of this kind, we understand that the height is very great, being upwards of one hundred feet.

GRAVITY, a term used by physical writers to denote the cause by which all bodies move towards each other, unless prevented by some other force or obstacle. Its effects on the motions of the celestial bodies are explained by astronomical writers. The most familiar effect, and that which continually obtrudes itself on our notice, is the weight of bodies, or their tendency towards the centre of the earth. Though the phenomena arising from the weight of bodies form the basis of a separate science called mechanics, yet they are of great consequence to the chemist. It has not been ascertained, or rendered probable, that gravity is a secondary property of matter; that is to say, that it flows from any of the other known original properties. Sir Isaac Newton, however, was of opinion, that our reasonings on the subject might be simplified, by supposing it to depend on a prodigiously elastic and rare fluid, by him called ether, and assumed to possess an increasing degree of condensation, in parts of space more and more remote from the various masses of matter. According to this doctrine, a falling body moves, because it is pressed towards the rarer parts of this extended fluid. We shall leave this theory to its merits, as being neither very perspicuous, nor much related to our subject. Bergman and others have considered the chemical and cohesive attractions to be one and the same with the attraction of gravity; but modified in its laws, by variations in the masses, densities, and distances of the particles of bodies. Many difficulties appear at first sight to offer themselves against this supposition. But in truth it cannot be examined at first sight; but requires to be submitted to the rigour of mathematical investigation. I do not know that any attempt of this nature has been made. See ATTRACTION.

GRAVITY, SPECIFIC. Boyle is among the first of our philosophers who suggested the advantage that chemistry and mineralogy might derive from an attention.

attention to the specific gravities of bodies. Much advantage may indeed be derived from this property in the general determination of the classes of minerals, and the purity of some metallic bodies; and it is very probable, that an attention to the specific gravities, capacities for heat, fusibilities, volatilities, laws of crystallization, elasticity, hardness, tenacity, malleability, and some other obvious specific properties of bodies, may produce a more intimate acquaintance with the mutual actions of their particles, than any we have hitherto acquired.

Annexed to this article is a table of specific gravities. In compiling this, I had Briffon's table at the end of Lavoisier's *Traité Elementaire de Chemie*, and Muschenbroek's large table in his *Cours de Physique*, before me. Some few specific gravities are from other authors, or from experiment. It appeared useless to carry it to more than four places of figures, as the temperatures were not noted; and the various specimens of the same substance often differ in the third figure. These assertions may be thought to require proof: for which reason I shall observe that, by experiment, I find that the fifth figure changes in water at every three degrees of Fahrenheit's thermometer; that lead, tin, and probably all other metals, though cast out of the same fusion, will vary in their specific gravities in the third figure, from circumstances not yet determined, but most likely from the cooling, as is seen in the hardening of steel; that salts, and other artificial preparations, retain more or less of the solvent they were separated from, according to the temperature at which the crystallization was effected; and that all parts of organized substances not only differ according to the place of their production, their age, and other circumstances, but likewise from their dryness, moisture, and manner of preservation.

The specific gravity of solids is determined by weighing them first in air, and then in water. The loss of weight arising from the action of the water, is equal to that of a mass of the fluid possessing the same dimensions as the solid itself. Whence it is easy to construct a general table of specific gravities, by reducing the proportion of the absolute weight to the loss sustained by immersion, into terms of which that expressing water shall be unity. If the solid be so light as to float upon water, it is convenient to attach to it another heavier body sufficient to cause it to sink, but whose weight in water must be added in computing the loss. The specific gravity of fluids is ascertained by weighing a known body immersed in them. For the loss by immersion will accurately shew the weight of the same bulk of the fluid; and, consequently, the proportion of these several quantities to the loss the same solid sustained in water, being reduced as in the other case to the common standard of unity, will exhibit the specific gravity. Other methods are likewise used in experiments with fluids. Thus equal bulks of different fluids may be weighed by filling a small bottle with a ground stopper with each respectively, and from their several weights the weight of the bottle and stopper must be deducted. Or otherwise, the instrument called the hydrometer may be used. *See* HYDROMETER. This possesses the advantage of portability, speed, and a degree of accuracy not easily obtained by the use of ordinary balances.

A T A B L E

Shewing the Specific Gravity of Metals and other Bodies to Rain Water, and the Weight of a Cubic Inch of each, in Parts of a Pound Averdupois.

Bodies.	Sp. Gravity.	W lb. Averd.	Bodies.	Sp. Gravity.	W. lib. Averd.
Pure gold cast	19258	0,71036	Muscovy talc	2792	0,10098
— hammered	19362	0,70030	Common slate	2672	0,09664
Standard gold cast	17486	0,63250	Calcareous spar	2715	0,09820
— hammered	17589	0,63618	Alabaster	2730	0,09874
Pure silver cast	10474	0,37796	White marble	2716	0,09823
— hammered	10511	0,38017	Limestones, from	1386	0,05113
Standard silver in coin	10391	0,37580	— to	2390	0,08644
Crude platina in grains	15602	0,56431	Ponderous spar	4474	0,16182
Platina purified and fused	19500	0,70530	Fluor spar	3180	0,11502
— hammered	20377	0,73557	Pumice-stone	914	0,03306
— drawn into wire	21042	0,76107	Green glafs	2620	0,09476
— laminated	22069	0,79821	English crown-glafs	2520	0,09115
Mercury	13568	0,49074	White flint-glafs, English	3290	0,11900
Lead fused	11352	0,40965	Another piece	3216	0,11632
Copper fused	7788	0,28163	White flint glafs for achroma- tic uses	3437	0,12431
— drawn into wire	8878	0,32111	White glafs, French	2892	0,10460
Brass cast	8396	0,30367	Glafs of S. Gobin	2488	0,09000
— in wire	8544	0,30903	Trinitone	1990	0,07198
Iron cast	7207	0,26067	Phosphorus	1714	0,06199
— bar	7788	0,28168	Yellow amber	1078	0,03899
Steel, soft, and not hammered	7840	0,28356	Distilled water	1000	0,03617
— hardened	7816	0,28270	Sea water	1026	0,03711
Tin, English, fused	7291	0,26371	Common spirit of wine	837	0,03027
— hammered	7299	0,26400	Spirit of wine, the purest that can be had by mere distilla- tion	820	0,2960
Malacca tin fused	7296	0,26382	Vitriolic ether	739	0,02673
— hammered	7306	0,26486	Nitrous	909	0,03288
Bismuth	9823	0,35529	Marine	730	0,02640
Nickel	8660	0,31323	Acetous	866	0,03132
Arfenick, the regulus	5763	0,20844	Concentrated vitriolic acid	2125	0,07686
Cobalt	7812	0,28255	— nitrous acid	1580	0,05714
Zinc	7191	0,26009	— marine acid	1104	0,04319
Antimony	6702	0,24240	Fluor acid	1500	0,05425
Manganese	6850	0,24776	Oil of olives	915	0,03309
Wolfran	17600	0,63657	— of sweet almonds	917	0,03316
Diamond	3251	0,11759	Linfeed oil	940	0,03400
Ruby	4283	0,15491	Naptha	708	0,02561
— Spinell	3760	0,13600	Gum elastic	393	0,03375
Topaz, oriental	4011	0,14507	Camphor	989	0,03577
— Brazillian	3536	0,11718	Yellow wax	905	0,03450
— Saxon	3564	0,12891	White ditto	969	0,03595
Sapphire, oriental	3994	0,14446	Spermaceti	943	0,03411
Emerald	2775	0,10037	Tallow	942	0,03407
Adamantine spar	4180	0,15118	Heart of oak	1170	0,04232
Rock crystal from Madagascar	2653	0,09596	Cork	240	0,0863
Quartz	2654	0,09599			
Agate	2590	0,09368			
Onyx	2376	0,09537			

GREAT WORK. A process for converting or transmuting metallic substances into gold. Chemistry possesses no facts tending to shew that any of the metals are convertible into each other; neither do we know of any which evince the absurdity of supposing such a conversion to be possible. The alchemists were doubtless misled, either by the desire of profit, or by the effect of a few delusive phenomena, or specious general reasonings, adapted to the infant state of chemistry. These hopes, these facts, and these reasonings, have not yet entirely lost their force with the ignorant. But the strongest terms are insufficient to describe or deplore the situation of those who may direct their exertions to a pursuit so much calculated to agitate and distress the mind, and possessing so little probability of success as the great work of the alchemists.

GRITT-STONE. A stone consisting of sand agglutinated together. Its properties differ according to the fineness or coarseness of its grain, and the firmness of its texture. Some kinds are pounded, to convert them again into sand; others are used for building, others for grinding edge tools, and others for filtering water.

GROWAN. A Cornish mine term, used to denote a compound stone, consisting of white clay mixed with mica, quartz, and of no particular texture. It is the greifs of the Germans.

GUHR. A loose calcareous earth found in the clefts or cavities of rocks, mostly of a white colour, but sometimes red or yellow, from a mixture of clay or ochre.

GUM. The mucilage of vegetables. It is usually transparent, more or less brittle when dry, though difficultly pulverable; of an insipid, or slightly saccharine taste; soluble in, or capable of combining with water in all proportions, to which it gives a gluey adhesive consistence in proportion as its quantity is greater. It is separable, or coagulates by the action of weak acids; insoluble in ardent spirit, or in oil; and capable of the acid fermentation, when diluted with water. The destructive action of fire causes it to emit much fixed air, and converts it into coal without exhibiting any flame. Distillation affords water, acid, a small quantity of oil, a small quantity of volatile alkali, and much coal.

These are the leading properties of gums, rightly so called; but the inaccurate custom of former times applied the term gum to all concrete vegetable juices, so that in common we hear of gum-copal, gum-fandarach, and other gums which are either pure resins, or mixtures of resins with the vegetable mucilage.

The principal gums are, 1. The common gums, obtained from the plum, the peach, the cherry-tree, &c.—2. Gum Arabic, which flows naturally from the acacia in Egypt, Arabia, and elsewhere. This forms a clear transparent mucilage with water.—3. Gum Seneca, or Senegal. It does not greatly differ from gum Arabic: the pieces are larger and clearer; and it seems to communicate a higher degree of the adhesive quality to water. It is much used by callico-printers and others.—4. Gum Adragant or Tragacanth. It is obtained from a small plant of the same name growing in Syria, and other eastern parts. It comes to us in small white contorted pieces resembling worms. It is usually dearer than other gums, and forms a thicker jelly with water.

Gums treated with a nitrous acid, afford the acid of sugar.

GUM, ELASTIC. Elastic gum is one of those substances which it is difficult to class. It burns like resins; but its softness, its elasticity, and its insolubility in the menstrua which usually dissolve resins, do not allow us to class it among those bodies.

The

The tree which affords it is known by the name of Seringa, by the Indians of Para. The inhabitants of the province of Esmeraldas, a province of Quito, call it Hhava; and those of the province of Mainas, Caoutchouc.

Mr. Richard has proved, that this tree is of the family of the euphorbia; and Mr. Dorthes has observed that the coccus, which are covered with a down that resembles small straws, were covered with a gum very much resembling the elastic gum. These insects feed on the euphorbium; but those which come from other situations afford the same juice.

We are indebted to Mr. Condamine for an account and accurate details concerning this tree. (Acad. des Sciences, 1751.) This academician informs us, after Mr. Fresneau, engineer at Cayenne, that the caoutchouc is a very lofty tree. Incisions are made in the bark; and the white juice, which flows out in a more or less liquid state, is received in a vessel placed for that purpose. This is applied in successive coatings upon a mould of clay, and dried by the fire or in the sun. All sorts of designs are traced upon it while soft; and when it is dry, the clay mould is crushed, and the pieces shaken out.

This gum is very elastic, and capable of great extension.

When elastic gum is exposed to the fire, it becomes soft, swells up, and burns with a white flame. It is used for illumination, instead of candles, at Cayenne.

It is not at all soluble either in water or alcohol. But Macquer has assured us, that ether is its true solvent; and upon this property he has instituted the art of making bougies, for chirurgical uses, of elastic gum, by applying this solution upon a mould of wax till it is of the requisite thickness.

Mr. Berniard, to whom we are indebted for important observations upon this substance, found only the nitrous ether, which dissolved elastic gum: very pure vitriolic ether did not perceptibly act upon it.

If elastic gum be put in contact with a volatile oil, such as that of turpentine, or even if it be exposed to the vapour of that fluid, it swells, softens, and becomes very pasty. It may then be spread upon paper, or applied as a varnish to cloth; but this covering preserves its adhesive quality, and does not lose it for a long time. The mixture of volatile oil and alcohol forms a better solvent than the pure oil, and the varnish dries more speedily.

Mr. Berniard has concluded, from his experiments, that the elastic gum is a fat oil, coloured by a matter soluble in alcohol, and soiled by the smoke to which the gum is exposed while drying.

If linseed oil be rendered very drying by digesting it upon the calces of lead, and it be afterwards applied by a small brush upon any surface, and dried by the sun, or in the smoke, it affords a pellicle of a considerable degree of firmness, evidently transparent, burning like elastic gum, and wonderfully elastic and distensible. If this very drying oil be left in a wide shallow vessel, the surface becomes thick, and forms a membrane which has the greatest analogy with the elastic gum. A pound of this oil spread upon a stone, and exposed to the air for six or seven months, acquired almost all the properties of elastic gum. It was used to make catheters and bougies; was applied to varnish balloons, &c.

GUM RESIN. Vegetable juices consisting of a mixture of gum and resin, or essential oil. These parts do not appear to be in a state of combination, for no menstruum completely dissolves the whole. If water be applied, by the assistance of trituration, the gummy matter is completely dissolved; and the resin being suspended in a state of minute division, exhibits the emulsive form.

Ardent spirit in like manner takes up the resinous matter; and the gum, for similar reasons, gives opacity to the fluid.

Macquer observes, that since the gum refins consist of principles not truly combined with each other, the compound must be opaque; and he therefore lays it down as a rule, that all transparent vegetable concretes are either pure gums or pure refins.

The principal gum refins are frankincense, scammony, assafoetida, aloes, gum ammoniac, and gamboge.

GUNPOWDER. This well known powder is composed of seventy-five parts, by weight, of nitre, sixteen of charcoal, and nine of sulphur, intimately blended together by long pounding in wooden mortars, with a small quantity of water. This proportion of the materials is the most effectual. But the variations of strength in different samples of gunpowder are generally occasioned by the more or less intimate division and mixture of the parts. The reason of this may be easily deduced from the consideration that nitre does not detonate until in contact with inflammable matter; whence the whole detonation will be more speedy, the more numerous the surfaces of contact. The same cause demands that the ingredients should be very pure, because the mixture of foreign matter not only diminishes the quantity of effective ingredients which it represents, but likewise prevents the contacts by its interposition.

The nitre of the third boiling is usually chosen for making gunpowder, and the charcoal of light woods is preferred to that of those which are heavier, most probably because this last, being harder, is less pulverable. The requisite pounding of the materials is performed in the large way by a mill, in which wooden mortars are disposed in rows, and in each of which a pestle is moved by the arbor of a water-wheel: it is necessary to moisten the mixture from time to time with water, which serves to prevent its being dissipated in the pulverulent form, and likewise obviates the danger of explosion from the heat occasioned by the blows. Twelve hours pounding is in general required to complete the mixture; and when this is done, the gunpowder is in fact made, and only requires to be dried to render it fit for use.

There are experiments which seem to shew, that gunpowder is stronger in the fine impalpable form than when granulated. This appears to be true with regard to gunpowder originally made, or pounded until it assumes that form; but it may be doubted whether it has any foundation in general, or indeed that the greater strength depends at all upon this form. The granulation of gunpowder is performed by placing the mass, while in the form of a stiff paste, in a wire sieve, covering it with a board, and agitating the whole: by this means it is cut into small grains or parts, which, when of a requisite dryness, may be rendered smooth or glossy by rolling them in a cylindrical vessel or cask. Gunpowder in this form takes fire more speedily than if it be afterwards reduced to powder, as may be easily accounted for from the circumstance, that the inflammation is more speedily propagated through the interstices of the grains. But the process of granulation does itself, in all probability, weaken the gunpowder, in the same manner as it is weakened by suffering it to become damp; for, in this last case, the nitre, which is the only soluble ingredient, suffers a partial solution in the water, and a separation in crystals of greater or less magnitude; and accordingly the surfaces of contact are rendered less numerous.

The detonation of gunpowder has been always an interesting problem in chemistry.

chemistry. Numerous theories have been offered, to account for this striking fact. But it is now very well settled, that the nitrous acid is decomposed by the heat of ignition; that its vital air combines with the charcoal, and forms fixed air, while the phlogisticated air, or other component part, becomes disengaged in the elastic form. Berthollet found, that the elastic product afforded by the detonation of gunpowder, consisted of two parts phlogisticated air, and one fixed air. The sudden extraction and expansion of these airs, is the cause of the effects of gunpowder. *See ACID NITROUS.*

The marine salt afforded by combining the dephlogisticated or aerated marine acid and vegetable alkali, affords gunpowder of much greater strength than the common nitre. For the method of making this salt, *see ACID-MARINE AERATED.*

GYPSEOUS EARTH, or GYPSUM. A combination of calcareous earth with vitriolic acid. As this salt requires about five hundred times its weight of water to dissolve it, the earlier chemists reckon it among the earths. But as its component parts and properties are now well known, gypsum is at present considered as an earth by chemists. *See EARTH CALCAREOUS.*

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H AIR. This animal excrement does not appear to differ considerably from horn, either in its obvious qualities or component parts. Water or ardent spirit have very little action upon it. But acids and alkalis act very strongly, more especially when assisted by heat. The nitrous acid totally dissolves hair; and if loaded with this substance by boiling, it deposits a gelatinous matter on cooling. By repeated abstraction of nitrous acid, a large proportion of acid of sugar is obtained. I have not met with an account of the properties of the combination of hair with caustic fixed alkali, which dissolves it.

Neumann examined, by destructive distillation, the hair of cows, horses, swine, and sheep, and also the human hair. He obtained volatile alkali, partly combined with water, and partly in the concrete state; some empyreumatic oil, and a coaly residue of difficult incineration, which afforded a small quantity of fixed salt. The proportions of these in each were different, but need not be here related, as the modern chemists would, no doubt, in repeating the experiment, attend to the elastic as well as to the condensible products.

HARDNESS may be defined as that property of bodies by which they resist indentation. It differs from tenacity, which is the opposite quality to brittleness, whereas hardness is the opposite quality to softness, or the disposition which the parts of a solid body possess of easily yielding without fracture. Chemists and others usually ascertain the comparative hardness of bodies by rubbing the one against the other; any angular prominence of a harder body being capable of scratching or making a mark upon the surface of a softer. This is not a bad method,

thod, though it may be rendered uncertain by the greater or less brittleness of the respective bodies. Thus hardened steel will scratch glass, and will in return be scratched by glass; the brittleness of the glass causing it to yield under the steel, which is more tenacious, though softer. On this principle likewise it is that the keenest edge tools, and those best calculated to cut hard bodies, are not hardened to the highest temper the steel is capable of, but to such a degree only as to retain much tenacity with a moderate hardness.

The mechanical philosophers, at the beginning of the present century, accounted for the hardness of bodies, by supposing their particles to be of such a form as to apply to each other with large surfaces of contact. This doctrine seems in some measure to be true, when applied to the crystals of bodies on their assumption of the solid form. Sugar-candy, or the more slowly formed crystals of sugar, are harder (or perhaps less brittle) than loaf sugar, in which the same small crystals are more confusedly applied to each other: calcareous spar is harder than chalk, &c. But how far this doctrine may apply to the hardness arising from the hasty crystallisation of steel and other bodies by immersion in water, remains to be settled by future researches.

Mr. Kirwan, in his Mineralogy, has exhibited the hardness of the different species of stones, as ascertained by Mr. Quist, by the impression made on each other. In the following table the stones, which stand first, are able to scratch or cut the succeeding, but not vice versa; and such stones, whose hardness does not exceed 11, may be scratched by steel. The first column denotes the hardness, and the second the specific gravity.

Diamond from Ormos	20		Sardonyx	- - - -	12	- 2.6
Pink diamond	- - 19	- 3.4	Amethyst	- - - -	11	- 2.7
Bluish diamond	- - 19	- 3.3	Crystal	- - - -	11	- 2.6
Yellowish diamond	- 19	- 3.3	Carnelion	- - - -	11	- 2.7
Cubic diamond	- - 18	- 3.2	Green Jasper	- - - -	11	- 2.7
Ruby	- - - - 17	- 4.2	Reddish yellow ditto		9	- 2.7
Pale ruby from Brazil	16	- 3.5	Shoerl	- - - -	10	
Spinell	- - - - 13	- 3.4	Tourmaline	- - - -	10	
Deep blue sapphire	- 16	- 3.8	Quartz	- - - -	10	- 2.7
Ditto paler	- - 17	- 3.8	Opal	- - - -	10	- 2.6
Topaz	- - - - 15	- 4.2	Chrysolite	- - - -	10	- 3.7
Whitish ditto	- - 14	- 3.5	Zeolyte	- - - -	8	- 2.1
Bohemian	- - - - 11	- 2.8	Fluor	- - - -	7	
Emerald	- - - - 12	- 2.8	Calcareous Spar	- - - -	6	
Garnet	- - - - 12	- 4.4	Gypfum	- - - -	5	
Agate	- - - - 12	- 2.6	Chalk	- - - -	3	
Onyx	- - - - 12	- 2.4				

HEAT. The sensations expressed in common language by the words heat and coldness, are of too simple a nature to require or to admit of definition. These words, however, are not always used to denote the same things; but are indiscriminately applied both to the sensation itself, or to that which causes it. Thus, we say, that we ourselves are hot or cold; and that the fire or ice which heats or cools us, is likewise hot or cold, though the sensations we experience are certainly very different things from that which enables bodies to excite them. It

may also be remarked, that, in this ambiguous manner of speaking, there is another cause of uncertainty that arises from the use of a variable standard of comparison. Every one knows, that the estimation of heat or coldness differs in various persons, because each forms his judgment from his own sensations; and the same body may appear hot to one person, and cold to another, or to the same person at different times; though the variation is not in the body itself, but in the state of the person in whom these sensations are excited. Hence it appears necessary, in order to avoid error in the pursuit of inquiries concerning heat, that the sense of the words made use of should be accurately defined, and that some fixed standard of comparison be made use of instead of the human body, which, though fixed enough for the common affairs of life, is certainly not enough so for the purposes of science.

The word heat, in a philosophical sense, is used to denote the cause of the power which bodies possess of exciting the sensations of heat or coldness.

The word temperature denotes the state of the body with respect to that power. So that a body which excites a more intense sensation of heat or coldness than another body, is said to possess a higher or lower temperature.

It has not yet been determined in what heat itself, or the cause of temperature, consists. Two opinions have long divided the scientific world. One is, that heat consists of a peculiar motion or vibration of the parts of bodies, so that the temperature is higher, the stronger the vibration. The other is, that heat is a substance or fluid, whose greater or less quantity produces a higher or lower temperature. The decision of this great question is highly deserving of the attention of philosophers. But it will not be necessary to consider its merits in our first steps of investigation, because the doubts respecting it will not impede our reasoning concerning such phenomena as are well known. For since effects are proportioned to their causes, we may speak of the quantities of heat in bodies, without deciding whether they be quantities of motion or quantities of matter; the relation of those quantities to each other, and not their peculiar nature, being the chief object of our research.

Two bodies which, when in contact, neither impart nor receive heat from each other, are of the same temperature. All bodies, therefore, which by direct or successive contact communicate with each other, must either have the same temperature, or the hotter will communicate heat to the others, till a common temperature is produced amongst them.

The disposition or power of quickly transmitting heat in the production of a common temperature, is not the same in different bodies. If a number of straight wires of equal sizes, but different metals, be covered each with a thin coat of wax, and their ends be plunged in the same heated fluid, for example, melted lead, the fusion of the coat of wax will shew that heat is more quickly transmitted through some metals than others. Thus also it is found, that the end of a glass rod may be kept red hot for a very long time, without any inconvenience to the hand which holds the other end; though a similar metallic rod, heated in the same manner, would very soon become too hot to be held. Bodies that quickly alter their temperature by communication, are said to be better conductors of heat than such as alter more slowly.

The general effects of a change of temperature are these: A solid is rendered fluid by an increase of temperature, and a still greater increase converts it into elastic fluid or vapour. If the body be composed of parts, which become solid,

fluid, or vaporous, at different temperatures; and the elective attraction, by which those parts are held together, be insufficient to prevent their assuming these states by the change of temperature, a separation will then take place: thus a diminished temperature separates salt from water, by their becoming solid; and an increased temperature separates water from salts, by causing the former to fly off in vapour. Lastly, if neither the change of temperature be considerable enough to alter the state of solidity, fluidity, or vapour which the body under consideration may happen to possess, nor the body itself be of the nature to undergo a separation of its parts by the change, then an increase of temperature will cause an increase in the bulk or dimensions of the body, which will last no longer than during the time of the increase.

It has already been observed, that the temperature at which different bodies change their form is various. Neither this property, nor the expansions of bodies by heat, have been observed to have any correspondence with their density, hardness, specific gravity, or other evident properties. There are, likewise, some irregularities in the contraction or expansion, which depend on circumstances not yet well ascertained, near the freezing point, of water, and probably other substances. Pure water, when cooled, is observed to contract till within about eight degrees of the freezing temperature, where it begins to expand; and it may be cooled eleven degrees below that temperature, and still continue fluid. An adequate explanation of the circumstances that attend the conversion of bodies from their several states of solidity, fluidity, and vapour, seems to promise a more intimate acquaintance with the nature and properties of the particles of bodies, than has hitherto been obtained.

Permanently elastic fluids, or airs, appear to differ from vapour in the circumstance, that they take and retain the elastic form at a lower temperature. There are facts which render it probable, from analogy, that a great degree of cold would convert them into dense fluids.

It is a self-evident truth, that, if two bodies be perfectly equal and alike in all respects, and have the same temperature, they will possess equal quantities of heat.

Thus, a pound of gold will possess an equal quantity of heat with another pound of gold at the same temperature, a pound of water will possess an equal quantity of heat with another pound of water at the same temperature, and so forth. From this it will also be clear, that two pounds of gold will possess twice as much heat as one pound of gold, at the same temperature; and generally, that the quantities of heat in bodies of the same kind, and at the same temperature, will be in proportion to their quantities of matter, or their weights.

If two such equal and similar bodies, that differ in temperature, be brought together, they will, by communication, acquire a common temperature, and their quantities of heat will by that means be rendered equal. For this purpose, it is clear, that the hotter of the two bodies must have communicated half its excess to the colder. The quantity of heat in one of the two equal bodies will therefore be an arithmetical mean between the two quantities originally possessed by each of them; that is to say, its temperature, or the common temperature, will exceed that of the colder exactly as much as it falls short of the hotter bodies.

If the two bodies had been unequal, they would nevertheless have acquired a common temperature by communication; but the excess of heat would not have been equally divided between them. For we have shewn, that the quantities of heat in such bodies, at the same temperature, are in proportion to the quantities

of

of matter. If the surplus of heat had been entirely taken away, it is obvious, that their temperature would have been made equal, and their heats would have been in that proportion; and there is no other way of adding the surplus to them, so as to preserve the same proportion, but by giving more to the larger than to the smaller body, according to its quantity. The common temperature that they acquire shews that this is done; and consequently, that, when two unequal bodies of the same kind acquire a common temperature by communication, the excess of heat in the hotter body is divided between them in proportion to their weights or quantities of matter.

From this it is likewise evident, that the quantities of heat required to be added to or taken from bodies of the same kind, to produce equal changes in their temperature, will be in proportion to their quantities of matter.

The foregoing deductions naturally lead us to the consideration of an instrument proper to show the temperatures of bodies. Such an instrument will require to be placed in contact with the body under examination, in order that it may acquire the same temperature. It is therefore an indispensable condition, that the instrument should be of that small bulk as not sensibly to heat or cool the body it touches; but that the common temperature of the instrument, and the body itself upon contact, may, without perceptible error, be taken for the original temperature of the body. Another condition equally requisite is, that every change of temperature shall be attended with some evident change in the instrument by which it may be ascertained. The expansions and contractions of bodies are the most convenient for this purpose. These, however, are small, and would require to be magnified by some mechanical or optical contrivance, if a solid body were made use of. But the smallest change in the bulks of fluids may be easily shown, by the happy expedient of including them in a bottle, whose neck is long and very narrow in proportion to the diameter of its body. On these considerations the thermometer is made. It consists of a glass ball or bottle with a long narrow tube or neck, and is partly filled with mercury, a fluid preferable to all others, from its unchangeableness, the regularity of its expansions, and its not soiling the tube. The expansions or contractions of the mercury are shewn by the rise or fall of its surface, which is measured by a graduated scale usually fixed to the tube. *See THERMOMETER.*

The determination of the correspondence between the degrees of the thermometer, and the actual variations of the heats of fluids, was first accurately determined by Mr. de Luc. By mixing equal quantities of water at different temperatures, he found that the thermometer very nearly indicated the arithmetical mean between the two temperatures, and consequently that its indications are such as truly correspond with the qualities of heat.

As these fundamental experiments cannot be too strictly examined, the following doubt remained to be considered, namely, whether the disposition to give out or to receive heat, were the same in water at all temperatures? because it is clear, that if this disposition be changed by heating or cooling, the temperature, or power to heat or cool other bodies, will not follow the same proportion as the quantities of heat; though it may be imagined, not without probability in the case, that correspondent irregularities in the expansions of the mercury may cause the thermometer to indicate the arithmetical means between the two expansions produced by an extreme temperature. But whatever irregularities may be supposed to counteract each other in these experiments with mercury and water, it is to the last degree improbable that the same compensation would

would be found; when the mean temperature is obtained by other methods. With this view, the celebrated Dr. Crawford* very carefully repeated and confirmed Mr. de Luc's experiments, made others with a like result, by using lint-seed oil instead of water, and also by producing the mean temperature permanently in air included in a cylinder formed of two equal parts, the upper of which was kept to the freezing point, by surrounding it with pounded ice, and the lower to the boiling water point, by surrounding it with a greater supply of steam than could be condensed by its contact. The near correspondence of these several methods; that the expansions of mercury in the thermometer are correspondent with the heat it receives.

Thus far we have attended only to the communication of heat between bodies of the same kind; but when two equal bodies of different kinds produce a common temperature by communication, it seldom happens that it proves to be an arithmetical mean between the two original temperatures. In such cases, it is evident, that the heat, which was communicated from one to the other, has not altered their temperatures equally, but has raised or lowered that of the one more than it has lowered or raised that of the other. And as the proportion between the number of degrees through which one of the two bodies is thus raised, and the other lowered, is found, by experiment, to be the same, however different the two original temperatures may have been, provided no change of form or chemical combination has been produced in either of them; it is a general consequence, that the quantity of heat required to alter the temperature of one of the bodies a single degree, or any other equal part, will be greater or less than would be required to produce the same change in the other body, in proportion as the changes produced by the communicated heat were less or greater.

The whole heat in each body, when they have the same temperature, must consist of the same number of degrees: the proportion between the whole heats of the bodies will, therefore, be the same as between the heats required to raise each of them a single degree: that is to say, the comparative heats of bodies, at the same temperature, will be in the inverse proportion of the number of degrees their temperature is altered by the transmission of the same quantity of heat.

To illustrate this by an example in round numbers: Suppose a pint of mercury, at the temperature of 136° , be mixed with a pint of water at 50° , the mean temperature will be 76° . The water, therefore, has been heated 26° , and the mercury has been cooled 60° , by the loss of the heat it imparted to the water. The absolute heat in one degree of the mercury will, consequently, be proportionally less than that of one degree of the water; because the very same heat, which has raised the water 26° in temperature, would raise the mercury 60 , if it could be returned again; and the whole heat contained in the mercury will be to that of the water in the same proportion of 26 to 60 . But, in the present experiment, equal bulks were used; and mercury is about thirteen times as heavy as water; and equal weights of mercury would contain only one thirteenth part of the heat. Twenty-six, divided by 13 , quotes 2 . Whence the comparative heats of mercury and water are in the proportion of about 2 to 60 , or 1 to 30 ; that is to say, a pound of mercury, at the same temperature, contains no more than one thirteenth part of the heat contained in a pound of water.

* On Heat. London, 1788. This valuable performance contains the theory and most of the facts relating to heat, and deserves to be made a part of the library of every natural philosopher.

It may be observed, that the term comparative heat is used to denote the proportion of the absolute quantity of heat in one body to that of another equal mass of matter at the same temperature, considered as a standard. The standard made use of is pure water in a fluid state. Some writers call this specific heat. The disposition or property by which bodies severally require more or less heat to produce equal changes in their temperature, is called their capacity for heat. These capacities are considered as the unknown cause of the difference in their comparative heats, to which they are consequently proportional.

It is found by experiment, that the capacity of the same body for heat is least when solid, greater when fused or fluid, and greatest of all when it becomes converted into vapour, or elastic fluid.

Also, when bodies unite by virtue of chemical attraction, their capacities are seldom the same as the sum of the capacities of the bodies, but almost always either greater or less.

As the experiments relating to the capacities of bodies cannot be here given at large, it will be proper to mention, by way of inference, some of the chief consequences of this most luminous doctrine; first premising, however, that these inductions have all been verified by experiment*.

The capacities of ice and fluid water are found to be as 9 to 10. Ice cannot, therefore, be converted into water, unless it be supplied with as much heat as is sufficient to answer the difference of capacity. Thus, if equal quantities of ice and water, both at the temperature of 32° , or the freezing point, be exposed in similar vessels, at the same distance from a fire, both will receive heat alike, and the ice will be melted into water at 32° , while the water in the other vessel will have its temperature raised to 178° . Here it is obvious, that the same heat which raised the water to 146° , was merely sufficient to supply the increased capacity of the ice; for which reason this last had not its temperature raised at all. If the experiment be more accurately made, by mixing equal weights of water at 178° and ice at 32° , the same consequence will follow; for the ice will be melted, and the common temperature will be 32° ; because the ice in melting receives no augmentation of temperature by absorbing the whole 146° of heat from the water, by virtue of its increased capacity when it becomes fluid.

And so, likewise, when water is frozen by the loss of its heat, communicated to a cold atmosphere or other contiguous bodies, the process of cooling goes on till ice begins to be formed; but during the whole time of the conversion of the water into ice, the temperature remains stationary, because the diminished capacity of the ice causes it to give out heat, the continual evolution of which supplies the refrigerating bodies with as much as their energy of cooling might otherwise have taken to cause a diminution of the temperature. When the whole is frozen, this supply of extricated heat ceases; and therefore the cause, that cooled the water at first, goes on in cooling the ice, till the common temperature is produced.

In all experiments, wherein the capacities of the same bodies are changed, and the difference between the quantities of heat in the same body, in both states, at one common temperature, is known in the degrees of the thermometer, we may derive the advantage of finding the absolute quantities of heat in degrees of the thermometer, or the number of degrees which any particular point or temperature is remote from the true zero, or point of absolute privation of all heat.

* For which consult Dr. Crawford's Treatise, already spoken of.

To illustrate this curious position, the experiments on ice and water, just related, may be made use of. The whole quantities of heat, in these two states, are as 9 to 10. It is plain, therefore, when water freezes, it must give out one-tenth of its whole heat; and this tenth part, by the experiment, is found to amount to 146° of Fahrenheit's thermometer; consequently its whole heat is ten times 146° , or 1460° ; when its temperature is 32° above Fahrenheit's zero. Whence the natural zero is at 1428° .

No direct experiment has yet been made to shew the capacity of steam with relation to water. An indirect experiment of Dr. Crawford makes it as $15\frac{1}{2}$ to 10*. It is accordingly found, that steam, in its condensation into water, gives out as much heat as would raise the temperature of an equal quantity of non-evaporable matter, of the same capacity as water, 914 degrees. This heat it must have taken up at its formation. Whenever water is heated, we may, consequently, consider the heat as disposed of in two ways. Part raises the temperature, and part is employed in supplying the elastic vapour which flies off with the heat its increased capacity requires at that temperature. The greater the quantity of steam, the larger will be the proportion of heat employed in this last way. Now it is found, that a difficulty attends the production of steam, in proportion as effective obstacles are opposed in the way of its expansion or escape. If the water be heated in a close vessel, such as the Digger of Papin, no steam will be formed; if there be a small hole for the steam to escape, there will be less formed than if the whole surface of the fluid were uncovered; and if the superincumbent atmosphere be removed, as in the vacuum of an air pump, the production will be greatest of all. In every case where the steam can escape, it will be produced, until the quantity of heat employed in forming the elastic state has become equal to the supply of heat communicated to the fluid it escapes from. At this period, the temperature of the fluid will become invariable, but the quantity of steam thrown off will, in like circumstances, be proportioned to the facility of its escape. The stationary heat of the fluid will be governed, not by the heat applied, but by the same facility of escape. Water in the open air boils violently, and acquires a fixed temperature at 212° of Fahrenheit. But this varies a little, as the weight of the air varies and opposes a different resistance to the steam. See THERMOMETER. It has been stated, and with some probability, that there would be no interval of fluidity between the solid and the vaporous states, if it were not for the pressure of the atmosphere.

From this principle of the enlarged capacity of vapour, it is easy to account for the cold produced by evaporation. Every one is acquainted with the cold produced by wetting the hand with water, and, still more, with spirits of wine. The hand is the source of heat to the water, and would raise its temperature to 95° , if no evaporation took place. But as the water flies off in steam, the stationary temperature is produced at a lower degree, for the reasons just mentioned. The hand must therefore receive the sensation of cold from the water which envelops it, and this sensation will continue till it is all evaporated.

Spirit of wine or ether, being more evaporable, have their stationary point of temperature lower than water in similar circumstances of exposure. The freezing of water by means of ether affords a striking instance of this effect. Water is included in a thin glass tube, and the outside of the tube is kept continually wetted with ether, by means of a bottle with a capillary tube in its neck,

* Crawford on Animal Heat, p. 270.

through which the ether is poured. The consequence of the speedy evaporation of this very volatile fluid is, that in a very short time the included water is suddenly converted into ice, even before a fire, or in the midst of summer.

There appears to be no difficulty in accounting for the cold produced by the evaporation of water from the surface of the hand; because it is perfectly analogous to the fact where a stationary temperature, or boiling point, is produced over a fire. But in the experiment with ether it may seem remarkable, that the refrigeration is carried to a point so far beneath that of every one of the surrounding bodies. This may, however, be explained from an attention to what is observed to happen with water. If water were inclosed in a strong metallic vessel, and surrounded on all sides with ignited coals, there is no doubt, from the general course of facts, but that it would become gradually hotter, until it either burst the vessel by its expansive force, or acquired a temperature equal to that of the coals. But if an hole be suddenly opened, after the temperature has increased beyond the common boiling-water point, it is found that a sudden extrication of steam takes place, and the fluid immediately falls to the temperature of boiling water. Now the ether, being much more volatile than water, may be considered, when confined in a bottle, to be in a state similar to that of water in Papin's Digester; and the surrounding bodies act upon the bottle like the coals in the former instance. The included ether acquires the common temperature, because it is prevented from assuming the vaporous state, and has not elasticity enough to break the vessel. But as soon as this fluid is set at liberty, it evaporates readily, and becomes cooled down towards a stationary degree of temperature; at which if acquired, the heat carried off by the vapour would be accurately equal to that supplied by the surrounding bodies. This temperature, at the surface of ether exposed in our climate, is, on account of its volatility, considerably below the freezing point of water; and therefore, whenever a thin stratum of ether is made to surround a small vessel of water, it is no wonder it robs it of so much heat as to congeal it in a short time.

The effect of freezing mixtures is another evident consequence of this doctrine of the change of capacities of bodies for heat. When common salt is added to water, in as large a quantity as can be dissolved, the brine is much more difficult of congelation than mere water; so much so, that it does not acquire the solid state until it is cooled as low as, 6° below 0° on Fahrenheit's scale; or 38° below the freezing point of water. Suppose now, that the salt be mixed, not with water, but with snow, or pounded ice. These two substances will be disposed to combine together as before, but much of the effect will depend on the temperature. If this be so low, as that the combination may preserve the solid state, the external parts in contact of each will indeed unite; but they will form a solid combination; that will effectually prevent the internal parts from approaching each other, and accordingly little or no perceptible progress will be made towards the union of the whole mass. But if, on the contrary, the temperature be higher than this, the combination will be the fluid brine, though the snow and ice were solid before; and this for the plain reason, that the brine requires a less heat to fuse it, than would have been requisite to fuse the ice alone. The assumption of the fluid state in these bodies will increase their capacity, and they will be disposed to deprive the surrounding bodies of heat; that is to say, they will be colder than before. If the quantity of snow and salt be considerable, and there be no bodies at hand which can readily supply the heats required, the brine first produced will cool the snow and salt in its vicinity; and these, when

liquefied, will cool the rest of the snow and salt still more effectually. When the temperature of the whole is by this process reduced as low as -6° , or the freezing point of the brine, the liquefaction will stop, or it will proceed more slowly or faster, in proportion as the requisite heat can be supplied. It may therefore be easily understood, that if a mixture of this kind be placed in a vessel, and a smaller vessel containing water be plunged in it, the cooling process will freeze the water. It is likewise evident, that such mixtures can descend in temperature no lower than a certain fixed degree, which is their own freezing point*.

There are other freezing processes effected by the mere liquefaction or solution of salts in water, which also appear to depend on the increased capacity of the salt, or more probably of the water contained in them†. Among a variety of processes of this kind described in the Philosophical Transactions, the following may be selected, not as the most powerful, but because the materials are cheap, and well known. Equal parts of saltpetre and sal-ammoniac are to be reduced to a fine powder. If four ounces of water be poured on three ounces of this mixture, the solution will sink the thermometer 36 degrees: and as it is easy in this country to have pump water, at any season, as cool as 50° , this addition will cool it to 14° , which is therefore sufficient to freeze water in a phial plunged in it. If the water cooled in a first process be used to reduce other water and salts to the temperature of about 32° , and these be applied to the performance of a second process, the temperature will be much lower, viz. 4° below 0° .

Without entering more largely into examples of the change of capacity for heat in bodies which are changed in their form or state of chemical combination, it may be observed in general, that as the powers of gravity and projection, in continual opposition to each other, produce all the varied effects of position, and its consequences, in the great system to which they are essential; so among the actions of the minute parts of bodies, the cohesive attraction and the energy of heat are in continual opposition, and are concerned in every process of change in their peculiar properties. It is certain, that the particles of bodies do not touch each other, but are held in equilibrio at a certain distance, which varies with the temperature, as is deduced from the expansions and contractions dependant on this cause. What might be the consequences of an extreme depression of temperature, we are not likely ever to discover, and conjecture leads us very little in the doctrine of heat. It may be observed, that the changes of capacity in bodies, when they take the solid, fluid, or vaporous state, are greatly conducive to the preservation of a more equal temperature, than would otherwise be found in the districts around us. The cold produced by evaporation mitigates and conducts to other parts the strong heats of the torrid zone, and the heat developed on the freezing of water prevents the cold countries from being cooled as far below the freezing point as might otherwise happen. If the capacities of water and ice were equal, the freezing of immense bodies of water would scarcely be progressive, but would take place the instant the whole was cooled to 32° ; and so likewise the thawing of immense bodies of snow, and of mountains of ice, would be performed in the short time of the transmission of heat requisite to elevate its temperature the minutest portion of a degree above the temperature of solidity.

* Crawford, p. 474.

† Walker, in *Philos. Trans.* vol. lxxvii and lxxviii.

There are various methods used to increase the temperature of bodies. The friction of two pieces of wood against each other in a turner's lath produces heat and flame. A nail may be made red hot by quickly hammering it, or by the action of a dry grindstone; and when flint and steel are struck together, small particles of the steel are separated, which are in a strong state of deflagration; and upon examination with the microscope are found to have been fused into hollow greyish balls. From these facts it appears, that as heat increases the dimensions of bodies, so the diminution of the magnitude of bodies by mechanical action, causes them to give out heat, which if suddenly extricated will even produce a strong state of ignition. The sun's light, concentrated by a lens or mirror, is found to produce the most astonishing effects, by raising the temperature of bodies; as does likewise the electric shock, both of which far exceed those of our furnaces. Many chemical mixtures, wherein a rapid combination and change of capacity take place, produce ignition and flame. But the operations of chemistry, and the arts that require an increase of temperature, are generally performed by the contact of bodies in a state of combustion. See COMBUSTION, AIR VITAL, and PHLOGISTON.

Light and heat differ from each other in their chemical effects, as many experiments shew. The heat produced in the focus of a mirror or lens is not exactly in proportion to the quantity of light, but in some measure depends on its direction; so that the same quantity of light at the focus, spread over an equal surface, will heat more than if either within or beyond it. Part of the heat of a fire, though not luminous, is thrown off in rays subject to the same laws of reflection as light, but not like it transmitted through glass. This is plainly shewn by interposing a pane of glass between a fire and the face of an observer. The light will pass through, but the heat will be intercepted, and will be employed in raising the temperature of the glass*. And accordingly the heat of the fire will not be increased in the focus of a speculum of glass, though a metallic speculum will produce a great effect. A bright table spoon may be used for this experiment, instead of a mirror. If two metallic concave speculums be so placed at a distance from each other, that their axis may coincide, and an iron heated below ignition be placed in the focus (of parallel rays) of one mirror, there will be an image of the iron formed in the focus of the other; at which if a thermometer be applied, its temperature will be raised. Whence it follows, that the heat radiating invisibly from the iron is governed by the same laws as the light which forms the image. It is likewise found, that a freezing mixture †, placed in the same situation, will depress the thermometer by the action of its focal image. This has been thought to evince the material nature of cold, which has in every theory been supposed to be the mere negation of heat. It does not, however, appear to prove any thing more, than that, in the present constitution of the world, heat is emitted in all directions by all bodies; and that the freezing mixture intercepts a portion, which would have passed through the focus of one mirror, and proceeded to the other. The freezing mixture does the same thing as to the heat, which a black substance would have effected with regard to light. A black substance in one focus would have been visible in the other; not by the emission of rays of darkness, but by the interruption and privation of as much light as would else have proceeded from its apparent place. See LIGHT.

* Scheele on Air and Fire, p. 70. Eng. translation.

† By M. Pictet, but I forget where mentioned.

Whether heat be matter or motion, is a question which has not yet been well settled. If heat be nothing more than an intestine or vibratory motion of the particles of bodies, its communication, or transmission, may be easily explained, and with much simplicity, from the general laws of motion. But its absorption and extrication in the phenomena of freezing, or combustion, in the latter of which a single spark of ignited matter may produce the most violent conflagration through an extensive town, do not seem to be as easily accounted for by the laws of motion, without hypothetical assumptions, as by the supposition of a peculiar matter called heat. It may, perhaps, be sufficient on this subject to observe, that the effects of heat will not easily admit of comparison or analogy with any of the other appearances in nature; but can only be examined by experimental research.

Attempts have been made to determine whether the weight of bodies is affected by the greater or less quantity of heat they may contain. Dr. George Fordyce * weighed about 1700 grains of water in a bottle hermetically sealed, when unfrozen, at the temperature of 32°, and in a room wherein the air was of the same temperature. The water being then frozen, was found to be near one sixteenth of a grain heavier. Sir Benjamin Thompson obtained the same conclusion, by counterpoising water against spirit of wine, and exposing the apparatus to a cold atmosphere, which froze the former. In this last experiment the only apparent cause of error seems to be, that the water might not at first be cooled so low as the spirit, in which case an ascending current of air might have rendered the water more buoyant. But this error, if it existed, tends to confirm the conclusion in which the water preponderated.

Hence it is seen, that heat diminishes the attraction of gravity, as it also does that of cohesion, and probably those observed in chemistry, though its operation in producing the fluid state is so favourable to combination, as to render the observation of this last effect difficult. Whether the operation of heat in the diminution of the power of gravity may have any perceptible effect in enlarging the distances and periodical times of the inferior planets, must be left to the determination of astronomers.

Here follows a table of the comparative heats, or capacities of bodies for heat, extracted from Dr. Crawford's work. In this table, the capacity of water is used as the standard of comparison or unity. The numbers will therefore denote the whole quantities of heat in equal weights of the several bodies respectively at like temperatures, admitting that the capacities remain unchanged at all temperatures; or they will denote the relative quantities of heat required to cause equal changes in the temperature of such bodies; and hence the changes of temperature caused by the loss or gain of equal quantities of heat will be inversely as those numbers.

T A B L E.

The Comparative Heats of Different Bodies.

Inflammable air	-	21,4000	Arterial blood	-	-	1,0300
Dephlogistified air	-	4,7490	Water	-	-	1,0000
Atmospherical air	-	1,7900	Fresh milk of a cow	-	-	,9999
Aqueous vapour	-	1,5500	Venous blood	-	-	,8928
Fixed air	-	1,0454	Phlogistified air	-	-	,7936

* Phil. Trans. lxxv. p. 362.

Hide of an ox with the hair -	,7870	Cinders -	,1923
Lungs of a sheep -	,7690	Ashes of cinders -	,1855
Lean of the beef of an ox -	,7400	Ruft of iron, nearly freed from	
Alcohol -	,6021	air -	,1666
Rice -	,5060	Wafhed diaphoretic antimony,	
Horse beans -	,5020	nearly freed from air -	,1666
Spermaceti oil -	,5000	Athes of the elm tree -	,1402
Duft of the pine tree -	,5000	Calx of zinc, nearly freed from	
Peas -	,4920	air -	,1369
Wheat -	,4770	Iron -	,1269
Barley -	,4210	Brals -	,1123
Oats -	,4160	Copper -	,1111
Vitriolic acid -	,4290	White calx of tin, nearly freed	
Pit coal -	,2777	from air -	,0990
Charcoal -	,2631	Regulus of zinc -	,0943
Chalk -	,2564	Athes of charcoal -	,0909
Ruft of iron -	,2500	Tin -	,0704
Wafhed diaphoretic antimony	,2272	Yellow calx of lead, nearly	
Calx of copper, nearly freed		freed from air -	,0680
from air -	,2272	Regulus of antimony -	,0645
Quicklime -	,2229	Lead -	,0352

HEDERÆ, GUM. Lemery fays, that this gum exfudes from incifions made in the hederæ arborea, or tree ivy, whence it is collected by the peaſants in Italy, Provence, and Languedoc. The account is confirmed by Pomet; but Neumann, from unſucceſſful enquiries made on his own travels, is diſpoſed to conſider the account as doubtful, though he learned that it was the produce of Sicily and the kingdom of Naples.

This gum reſin, when genuine, is of a bright transparent reddiſh brown colour, deeper than the hyacinth, and approaching to the garnet; when reduced to powder, of a ſaffron yellow, and of an agreeable aromatic taſte and ſmell. From an ounce of this, Neumann obtained five drams and a half of reſinous extract by ſolution in ardent ſpirit, and of the reſidue water took up half a dram, and left two drams of inſoluble reſidue. When water was applied firſt to another ounce, it took up two drams of gummy matter, and of the reſidue ſpirit diſſolved three drams two ſcruples, and left two drams and half a ſcruple undiſſolved. By diſtillation with ardent ſpirit, the fluid came over with a ſlight taſte of the gum reſin. Water diſtilled from the hederæ was conſiderably impregnated both with the taſte and ſmell, and brought over a ſmall quantity of eſſential oil, lefts hot to the taſte than other oils of that claſs.

HELIOTROPIUM. The dyers uſe a blue paſte under the name of Litmus, which is ſuppoſed to be prepared from the heliotropium tricoceum, which grows wild about Montpellier. According to M. Niſſole of the French Academy, quoted by Savary in his Dictionnaire de Commerce, the colouring juice is obtained from the tops of the plant, gathered in Auguſt, ground in mills, and then committed to the preſs. The juice is expoſed to the ſun for about an hour; rags are then dipped in it, dried in the ſun, moiſtened by the vapour which ariſes from the ſlaking of quick lime with urine, then dried again in the ſun, and dipped again in the juice. The Dutch and others are ſaid to prepare turnſole

rags,

rags, and turnsole in the mafs, from different ingredients, of which archil is the chief. *See* ARCHIL.

The account of the rags or cloth of turnsole, as given by Chaptal *, states, that they are prepared by impregnating them with the juice of *morelle*, and exposing them to the vapour of urine, which develops their blue colour. These rags are exported to Holland, not for the use of the makers of turnsole, as is commonly supposed, but for the dealers in cheese, who extract a colour by infusion, and wash their cheeses with it to give them a red colour. He was convinced by experiment, that the colouring matter of the turnsole paste is of the same nature as that of archil; and found that by causing the lichen *parcellus* of Auvergne to ferment with urine, lime, and alkali, he could obtain a paste similar to that of turnsole. The addition of alkali appears to be necessary to prevent the development of the red colour, which, when combined with the blue, forms the violet of the archil.

The attention of chemists is more particularly directed to this substance, on account of its affording one of the most usual tests of the presence of acidity. The tincture of turnsole is prepared by lightly infusing the turnsole or litmus in water. If the water be too highly charged with the colouring matter, the infusion has a violet tinge, and must in that case be diluted with water until it becomes blue. Exposure of this infusion to the sun, even in closed vessels, turns it red, and some time afterwards the coloured matter falls down in the form of a discoloured mucilage. Ardent spirit may be used instead of water in this preparation.

It is scarcely requisite to direct the intelligent beginner in the use of this and other tests. Paper may be stained with it, and a drop of the supposed acid will turn it red. Or the liquids may be mixed in greater or less quantities, as convenient. This blue liquor may be made a test for alkalis, if it be first reddened by the addition of a small portion of vinegar or other acid. Alkalis restore the blue colour.

For another test, *see* BRASSICA RUERA.

HELLEBORE. Two ounces of the root of white hellebore yielded with water nine drams and one scruple of gummy extract; and the same quantity of root yielded with spirit of wine seven drams of resinous extract. From six ounces of the roots of black hellebore, six drams and one scruple were extracted by spirit; and from the same quantity of root, six drams and two grains were extracted by water. Borrichius relates, that the distilled water of the entire plant possesses emetic and purgative virtues. The root is a stimulating cathartic. Neumann.

HEPAR. The combination of sulphur with an alkali was denominated *Hepar Sulphuris*, or Liver of Sulphur, from its brown-red colour. Chemists have applied the term *hepar* in a general way to all combinations of alkali or earth with sulphur, or with phosphorus. *See* SULPHUR, PHOSPHORUS, AIR HEPATIC, AIR PHOSPHORIC.

HEPATIC AIR. *See* AIR HEPATIC.

HOMBERG'S PHOSPHORUS. The combination of lime and marine acid, which remains after distilling the volatile alkali from sal ammoniac, has usually an over-proportion of lime. If it be urged by a violent heat it fuses; and when cold it has the property of emitting a phosphoric light when struck with any

* Chemistry, i. 190.

hard body. It is called Homberg's phosphorus, from the name of the first observer of the fact.

HONEY. Honey is contained chiefly in the base of the pistil or female organ of flowers. It serves as food for most insects which have a proboscis. It appears to consist of sugar, mucilage, and water. The sugar sometimes separates in crystals.

Honey is supposed to have undergone no alteration in the body of the bee, as it retains the odour, and not unfrequently the qualities, of the plants it was gathered from.

Thirty six ounces of honey diluted with four quarts of warm-water, and fermented with a little yeast, yielded on distillation a pint of watery spirit, which by rectification was reduced to eight ounces.

HOOFS of ANIMALS. The hoofs of animals are composed of a substance nearly of the same nature as Horn, which see. They are not applied to any use, but to afford animal coal in the preparation of the Prussian alkali, and in the case-hardening of iron.

HOPS. It is universally taken for granted, that hops render beer less liable to change and become sour. Neumann affirms the same thing, and that it sensibly increases the spirituousity. It is well known that the aromatic bitter of the hop is an agreeable and probably a wholesome addition to beer: but the rest remains yet to be proved by experiment.

HORN. Among the consistent parts of animals, we observe a resemblance in the general properties of such as appear to be divested of sensation, namely, the bones, horns, hoofs, hair or wool, and skin. Some bony substances are very hard, and appear to consist of much phosphorated lime, together with about one sixth of their weight of proper jelly or glue, soluble in hot water as well as cold. Ivory, which is softer, contains about one fourth of its weight of glue. Hartshorn, which approaches as much to the nature of bone as horn in its obvious properties, affords about one fifth, and skin appears to afford most of all. Horn is said to afford no glue*. This substance differs from bone in its remarkable elastic flexibility, and the softness it acquires by a moderate heat. It seems to be of the same nature as hair; and if the fact of its affording no glue were well established, it would afford ground to think, that its earthy part is combined with a large quantity of serous, or fibrous matter, in the coagulated state. See *SERUM*.

Macquer asserts, that horn may be entirely converted into jelly, by treatment with water, in Papin's Digester. What happens in this process requires to be examined. Neumann found that twenty-five grains of an extract, of a brownish colour and saline taste, were obtained by boiling half an ounce of cow's horn in water. When treated in the dry way, horn affords the same products nearly as other animal matters, namely, an aqueous alkaline liquor, concrete volatile alkali, and a fetid oil, which, by repeated rectifications, becomes more and more limpid and clear.

Tortoiseshell, whalebone, and the hoofs of animals, appear to be nearly of the same nature as horn.

HORNBLLENDE, or HORNSTONE. This forms the tenth species of the argillaceous genus of Kirwan's System of Mineralogy. Its general characters, besides a partial solubility in acids, without effervescence, and an hardness never

* *Annales de Chimie*, xii. 212; also Neumann's *Chemistry*, ii. 336.

sufficient to strike fire with steel, are, 1. a specific gravity, never less than 2.66, and in many specimens as high as 3.88; 2. a strong earthy smell, when breathed upon, or wetted with hot water; 3. a toughness when pounded in a mortar, resembling that of mica or horn, from which property it obtained its name; 4. its affording a greenish grey powder, when pulverized; 5. fusibility without addition, as it is said; though Mr. Kirwan could not fuse it with the blow-pipe. It is frequently mixed with pyrites. Of this species the author reckons three varieties.

Variety 1. Black hornstone. *Corneus nitens Wallerii*. Its texture is lamellar, or granular: the former is sometimes so soft as to be scraped with the nail; its surface is frequently as glossy as if it had been greased: its specific gravity from 3.6 to 3.88, and it possesses all the specific properties in a high degree. With nitre it does not detonate. When heated it becomes of a snuff colour, and then slightly effervesces with diluted nitrous acid: its solution in this acid is of a greenish colour.

Mr. Kirwan boiled the powder of this stone in water, with a view to ascertain the principle on which its smell depends. The water was not altered in taste, nor did it exhibit any change by the tests he applied to it. By analysis he found that 100 grains of the lamellar sort contained 37 flint; 22 clay; 16 magnesia; 2 mild calcareous earth, and 23 calx of iron, not much dephlogisticated.

Variety 2. Greenish grey hornstone. This is of a granular texture, or striated. The specific gravity of the purest specimen Mr. Kirwan could find was 2.683. It is not so soft as the softest of the former variety. He suspects the common pale greenish grey whetstone to be of this species. It is of a close granular texture, exhales an earthy smell, affords a greenish powder, does not effervesce with acids, nor give fire with steel. Its specific gravity is 2.664. It contains 65 per cent. of flint.

Variety 3. Killas. This stone is of a pale grey, or greenish grey. Its texture either lamellar, or coarsely granular; the lamellar is softer and less martial than the roof slate. Its specific gravity is from 2.63 to 2.666. Mr. Kirwan found 100 grains of the lamellar sort to contain about 60 flint, 25 clay, 9 magnesia, and 6 iron. The greenish sort contains more iron, and gives a greenish colour to the nitrous acid.

HOURS, MINERALOGICAL. The direction of veins, with respect to the meridian, is in the language of miners denoted by hours. The circle of the horizon is divided into twice twelve hours. The north and south directions are denoted by twelve, and consequently the east and west by six o'clock.

HYDROGENE. In the new nomenclature this word denotes the principle to which inflammable air owes its characteristic. In the elastic state, according to the antiphlogistic theory, it is supposed to be united with the matter of heat, and generally holds water in solution or suspension. In combination with vital air, it forms water. See **AIR INFLAMMABLE**.

HYDROMEL. A fermented liquor made of honey and water. It is more commonly known by the name of Mead.

HYDROMETER. The best method of weighing equal quantities of corrosive volatile fluids, to determine their specific gravities, appears to consist in inclosing them in a bottle with a conical stopper, in the side of which stopper a fine mark is cut with a file. The fluid being poured into the bottle, it is easy to put in the stopper, because the redundant fluid escapes through the notch, or mark, and may be carefully wiped off. Equal bulks of water, and other fluids, are by

this means weighed to a great degree of accuracy, care being taken to keep the temperature as equal as possible, by avoiding any contact of the bottle with the hand, or otherwise. The bottle itself shews with much precision, by a rise or fall of the liquid in the notch of the stopper, whether any such change has taken place. See GRAVITY SPECIFIC.

But as the operation of weighing requires considerable attention and steadiness, and also a good balance, the floating instrument called the hydrometer has always been esteemed by philosophers, as well as men of business. It consists of a hollow ball, either of metal or glass, capable of floating in any known liquid: from the one side of the ball proceeds a stem, which terminates in a weight, and from the side diametrically opposite proceeds another stem, most commonly of an equal thickness throughout. The weight is so proportioned, that the instrument may float with the last mentioned stem upright. In the less accurate hydrometers this stem is graduated, and serves to shew the density of the fluid, by the depth to which it sinks; as the heavier fluids will buoy up the instrument more than such as are lighter. In this way, however, it is clear, that the stem must be comparatively thick, in order to possess any extensive range. For the weight of vitriolic ether is not equal to three-fourths of the same bulk of water; and therefore such an hydrometer, intended to exhibit the comparative densities of these fluids, must have its stem equal in bulk to more than one-fourth of the whole instrument. If this bulk be given chiefly in thickness, the smaller differences of density will not be perceptible; and it cannot, with any convenience, be given in length.

To remedy this imperfection, various contrivances have been proposed, for the most part grounded on the consideration, that a change in the ballast or weight employed to sink the ball, would so far change the instrument, that the same short range of graduations on a slender stem, which were employed to exhibit the densities of ardent spirit, might be employed in experiments upon water. Some have adjusted weights to be screwed upon the lower stem; and others, with more neatness and accuracy, have adjusted them to be slipped upon the extremity of the upper stem. But the method of Fahrenheit appears to be on all accounts the simplest and most accurate.

The hydrometer of Fahrenheit consists of an hollow ball, with a counterpoise below, and a very slender stem above, terminating in a small dish. The middle, or half length of the stem, is distinguished by a fine line across. In this instrument every division of the stem is rejected, and it is immersed in all experiments to the middle of the stem, by placing proper weights in the little dish above. Then as the part immersed is constantly of the same magnitude, and the whole weight of the hydrometer is known; this last weight added to the weights in the dish, will be equal to the weight of fluid displaced by the instrument, as all writers on hydrostatics prove. And accordingly the specific gravities for the common form of the tables will be had by the proportion:

As the whole weight of the hydrometer and its load, when adjusted in distilled water,

Is to the number 1,000, &c.

So is the whole weight when adjusted in any other fluid

To the number expressing its specific gravity.

In order to shew the degree of accuracy an instrument of this kind is capable of, it may in the first place be observed, that the greatest impediment to its sensibility arises from the attraction or repulsion between the surface of the fluid and that

that of the stem. If the instrument be carefully wiped with a soft clean linen cloth, the metallic surface will be equally disposed to attract or repel the fluid. So that if it possess a tendency to descend, there will be a cavity surrounding the stem; or if, on the contrary, its tendency be to rise, the fluid will stand round the stem in a small protuberance. The operator must assist this tendency, by applying the pincers, with which he takes up his weights, to the rim of the dish. It is very easy to know when the surface of the fluid is truly flat, by observing the reflected image of the window, or any other fit object seen near the stem in the fluid. In this way the adjustment of the weights in the dish may, without difficulty, be brought to the fiftieth part of a grain. If, therefore, the instrument displace 1000 grains of water, the result will be very true to four places of figures, or even to five. This will be as exact as most scales are capable of affording.

Some writers have spoken of the adjustment of an hydrometer of this kind, so that it shall at some certain temperature displace 1000 grains of water, as if this were a great difficulty. It is true, indeed, that the performance of a piece of workmanship of this nature would require both skill and judgment on the part of the artist: but it is by no means necessary. Nothing more is required on the part of the workman, than that the hydrometer shall be light enough to float in ether, and capable of sustaining at least one third of its own weight in the dish, without oversetting in a denser fluid. This last requisite is obtained by giving a due length to the stem beneath, to which the counterpoise is attached. With such an instrument, whatever may be its weight, or the quantity of water it displaces, the chemist may proceed to make his experiments, and deduce his specific gravities by the proportion before laid down. Or to save occasional computation, he may once for all make a table of the specific gravities, corresponding to every number of the load in the dish, from one grain up to the whole number of grains, so that by looking for the load in one column, he may always find the specific gravity in the column opposite. I find this method very ready and convenient in practice: but, if it be preferred, the weights may be adjusted to the hydrometer, so as to shew the specific gravity, without computation or reference. For this purpose the hydrometer must be properly counterpoised in distilled water, at the assumed standard temperature; suppose 60°, and the whole weight of the instrument and its load called 1.000, &c. Then the weight of the instrument and its load must be separately determined in grains and parts, or other weights, by a good pair of scales. And as the whole weight of the instrument and its load is proportioned to the weight of the instrument alone; so will be the number 1.000, &c. to a fourth term expressing the weight of the instrument in such parts as make the whole 1.000, &c. Make an actual set of decimal weights (see BALANCE, page 191, § 16, 17), of which 1.000, &c. shall be equal to the hydrometer and its load. And it is clear, that whatever may be the load in these weights, if it be added to the number denoting the weight of the instrument, the sum will denote the specific gravity of the fluid, wherein the instrument floats with that load.

By following the above easy method it will be found, that every hydrometer, whosoever made, must give the same results. The subject is indeed in itself sufficiently simple, and would require scarcely any discussion, if it had not happened that many philosophers, for want of requisite attention, have made their experiments with hydrometers graduated on the stem, by no certain rule by which operators at a distance from each other might compare their experiments. The

hydrometers, or *pèse-liqueurs* of Baumé, though in reality comparable with each other, are subject in part to the defect, that their results, having no independent numerical measure, require explanation to those who do not know the instruments. Thus, for example, when a chemist acquaints us that a fluid indicated 14 degrees of the *pèse-liqueur* of Baumé, we cannot usefully apply this result, unless we have some rule to deduce the correspondent specific gravity: whereas we should not have been in any respect at a loss, if the author had mentioned the specific gravity itself. As a considerable number of French philosophers refer to this instrument, it will be of use to explain its principles.

M. Baumé * appears to have directed his attention chiefly to the acquisition of a means of making hydrometers with a graduated stem, which should correspond in their results, notwithstanding any differences in their balls or stems. There is little doubt but he was led into the method he adopted, by reflecting on that by which thermometers are usually graduated (see THERMOMETER). As thermometers are graduated, independent of each other, by commencing with an interval between two stationary points of temperature, so M. Baumé adopted two determinate densities for the sake of marking an interval on the stem of his hydrometer. These densities were those of pure water, and of water containing $\frac{1}{11}$ parts of its weight of pure dry common salt in solution. The temperature was 10 degrees of Reaumur above freezing, or 57° of Fahrenheit. His instrument for salts was so balanced, as nearly to sink in pure water. When it was plunged in this saline solution, the stem arose in part above the surface. The elevated portion was assumed to be 15 degrees, and he divided the rest of the stem with a pair of compasses into similar degrees.

It is unnecessary to enquire in this place, whether this interval be constant, or how far it may be varied by any difference in the purity, and more especially the degree of dryness, of the salt. Neither will it be requisite to enquire how far the principle of measuring specific gravities by degrees representing equal increments, or decrements, in the bulks of fluids, of equal weight but different specific gravities, may be of value, or the contrary. It does not seem probable that Baumé's instrument will ever become of general use; for which reason nothing farther need be ascertained, than the specific gravities corresponding with its degrees, in order that such experiments as have this element among their data, may be easily understood by chemical readers.

M. Baumé's hydrometer for spirits was constructed from an interval of ten degrees experimentally found as above, by dissolving ten parts by weight of common salt, in ninety of water. I find by experiment, that this solution affords a division which does not differ from that before obtained from the solution of fifteen parts of salt in eighty-five of water. I find also, that the specific gravity of this last-mentioned solution, at the temperature of 57° Fahrenheit, is 1.105. Whence I have computed the following table:

* *Éléments de Pharmacie* : cinquième édition, Paris 1764, page 396.

TABLE of Specific Gravities, corresponding with the Degrees of the Hydrometers, or Pefe-Liqueurs of Baumé.

	Deg.	Sp. Gr.	Diff.		Deg.	Sp. Gr.	Diff.
Hydrometer for ardent Spirit.	45	- 0.778	- 20	Hydrometer for Salts.	20	- 1.145	- 43
	40	- 0.798	- 21		25	- 1.188	- 46
	35	- 0.819	- 22		30	- 1.234	- 51
	30	- 0.841	- 22		35	- 1.285	- 54
	25	- 0.863	- 25		40	- 1.339	- 59
	20	- 0.888	- 25		45	- 1.398	- 64
	15	- 0.913	- 28		50	- 1.462	- 71
	10	- 0.941	- 28		55	- 1.533	- 78
	5	- 0.969	- 31		60	- 1.611	- 87
	0	- 1.000	- 33		65	- 1.698	- 96
	5	- 1.033	- 34		70	- 1.794	- 108
	10	- 1.067	- 38		75	- 1.902	- 122
	15	- 1.105			80	- 2.024	

It muſt be remarked, with regard to this table, that the degrees of the hydrometer at which Baumé found his pureſt ardent ſpirit, correſpond with a ſpecific gravity ſo much higher than that of any ſpirit I have ever heard of, that I am diſpoſed to ſuſpect an inaccuracy in the principle on which the inſtrument is to be conſtructed.

There are a variety of hydrometers uſed for determining the ſtrength of ardent ſpirits. See SPIRIT ARDENT.

HYDROPHANES. This ſtone, which is alſo called oculus mundi, and lapis mutabilis, was formerly of great value. Its diſtinguiſhing characteriſtics that of becoming transparent by immerſion in water. Bergman has written a diſtinct treatiſe upon it.

The hydrophanes is either of a whitish brown, yellowish green, milky grey, or yellow colour, and opaque. Some ſpecimens give fire with ſteel. Its ſpecific gravity is about 2.048, and it is eaſily cut and poliſhed. Without addition, it is infuſible; but the flame of the blow-pipe changes it into a brown brittle ſubſtance. Neither acids nor alkalis have any action upon it in the humid way.

Three of theſe ſtones are to be ſeen in the Britiſh Muſeum in London. The largeſt is about the ſize of a cherry ſtone, but of an oval form. It is opaque, and in colour reſembling the common yellow pea. It may be ſcratched, though not without difficulty, with a knife, but it ſeems to leave a trace upon common glaſs. The acid of nitre does not cauſe any ebullition when applied to it.

When it has lain in water ſome hours it becomes transparent, and of a yellow amber colour. This change begins ſoon after the immerſion, and at one end, in the form of a ſmall ſpot (but in a ſmall one of the ſame kind the beginning is round the edges), which increaſes by flow degrees, till the whole ſtone has become uniformly clear throughout. When taken out of the water, it loſes its transparency, firſt at one end, and then gradually over the remainder. This change happens in leſs time than is required to produce the transparency, as

might

might indeed be naturally expected. For the stone cannot become transparent, until the water has soaked through its whole substance; but it becomes opaque, as soon as a certain thickness from the surface is well dried.

There is no doubt but this phenomenon is produced in the same way as oil or water renders paper transparent. It depends on a general principle, which is well explained by Sir Isaac Newton, in his Optics, viz. that all porous bodies may be rendered transparent, by filling their pores with some other matter of nearly the same density. For in this last case the light passes through with very little impediment, or deviation; whereas it was before subject to reflection and refraction at all the surfaces of the grosser particles, and therefore became absorbed and lost. That the hydrophanes absorb moisture, and emits air, which is a fluid of much less density, is evident from the weight it acquires, and the small bubbles which cover its surface during the time it acquires transparency.

These facts evidently shew that the effect arises from a coarse porosity in the structure of this stone. It is a general circumstance, that those siliceous stones which resemble the common flint in breaking smoothly and equally, are frequently surrounded by a covering of coarser material. Bergman thinks these coarser parts were extruded by the contraction of the more homogeneous matter, during the gradual transition from the soft to the hard state. It is not easy to form any notion of a mechanical action of this kind; and it seems more probable that the coarseness, or rather porosity, of these external crusts may have arisen from the action of water, air, or other agents, which during a long course of time may have carried off some of the parts to a certain depth, or have cracked, split, or destroyed the continuity to a certain depth, as is seen upon the surface of broken flints, and other stones exposed to the weather. These crusts must necessarily differ in texture, density, and hardness; and accordingly it cannot be expected, that the requisites of the hydrophanes should be very frequently met with. The proper pieces, which are generally surrounded with such as are useless, cannot be distinguished by their external appearance; but such as do not adhere to the tongue may be rejected. Immersion in water for a day will determine their quality, because such as require a longer time to become transparent are of no value.

Though it is probable that the crusts of all the varieties of siliceous stones may yield the hydrophanous stone, yet experience shews that it is chiefly to be sought for among those of a loose texture, such as opals and chalcidonic. The opal gives admittance to water, but wants the opacity requisite to make the experiment striking. If it be rendered opaque by fire, which must be very cautiously and gradually applied, it becomes the hydrophanes. Too sudden heat causes it to fly in pieces.

Bergman found the same component parts in the opal and the hydrophanes. He reduced the stone to a very fine powder, and separated 100 grains of the most subtle particles by elutriation. He formed this into a ball, with three times as much mineral alkali, and a little water, and exposed it for an hour and half in an iron vessel to a fire gradually raised, but not to such a degree as to melt the mass. If this last event should happen, which it is difficult to prevent, the fluid becomes loaded with iron, and is so troublesome to analyse, that it is better to repeat the process as at first, but with more care. After a certain time the ball splits again into a powder, by the dissipation of part of the alkali. In this powder the siliceous earth was combined with alkali, and the other earths were rendered much more accessible to acid menstrua, from which the silex might have

have defended them. By digestion of the powder in marine acid, he found that sixteen parts of argillaceous earth were taken up, and eighty-four parts of siliceous earth remained untouched. There was not the smallest appearance of any thing calcareous.

The value of the hydrophanes is estimated by its bulk, the quickness of the change, and the beauty of its colour. Of two equally penetrable, the larger must be longer in becoming transparent; but the effect may be increased by giving them a flat thin figure. The colour is derived from iron. Hot water produces the effect more speedily than cold. If frequent repetition of the experiment should render the stone less disposed to become transparent on immersion, it will most probably have arisen from calcareous deposition; in which case it may be cleared by immersion in acids. Alkalis, or acids, penetrate this stone, and render it transparent; the concentrated vitriolic acid renders it permanently so, by attracting water from the atmosphere. But the opacity may be restored by immersing it in an hot alkaline liquor. Nitrous acid highly concentrated calcines the iron, and alters the colour of this stone, by that means producing various shades of yellow. Bergman thinks that acids, by dissolving part of the argillaceous earth, may improve the quality of such stones as admit the water too slowly.

This stone probably received the name of *oculus mundi*, from an internal spark, or luminous spot, which changes its position according to the direction of the incident light. Bergman has made the most accurate remarks on this phenomenon, and finds that it proceeds from the caustic curves, and focal image, by refraction from the usual rounded form of the stone, and rendered visible by the semi-opacity of the material through which the light passes.

Though this mutability is chiefly found in stones of the siliceous order, yet as it depends upon the mechanism or construction, rather than the component parts, it may naturally be expected to be met with in the other orders. The requisites are, that transparent particles should be so joined, or agglutinated together, as to leave innumerable minute interstices capable of admitting water. This construction is sometimes met with among the steatites. It may easily be understood how this may be rendered transparent, as more than half its weight consists of siliceous particles, frequently pellucid. But the hydrophanous steatites, being loaded with magnesia, seldom acquires the same degree of transparency as those which almost entirely consist of siliceous earth, which are likewise harder, though less beautiful and various in their colours. Dr. Bruckman, quoted by Bergman, mentions red, white, green, and grey steatites possessed of this property. He directs that they should be first boiled in an alkaline lixivium, and then in vinegar.

I

I C E

I C E

ICE. Water in the solid state. Mairan observed that water, in freezing, has a tendency to form angles of sixty degrees, and to form stars with six rays. Romé de Lisle calculates, that the primitive form of ice is an equilateral eight-sided figure. Haffensratz has observed, that water, when it freezes under favourable circumstances, always assumes an hexahedral prismatic form. This fact is not inconsistent with the deduction of R. de Lisle.

The specific gravity of ice being considerably less than water, it always floats at the surface, where it is most commonly formed in consequence of the superior coldness of the atmosphere. It may nevertheless be formed at the bottom or side of any vessel, if the temperature be more effectually diminished in those parts than elsewhere, as by a freezing mixture. Ice is sometimes formed at the bottom of running waters, which Hales explains by remarking, that the superior parts of stagnant waters, as also of the earth, are colder in frosty weather than the inferior; but in running waters the uppermost parts are mixed with the lower, and all are cooled nearly alike; and as the water at the surface flows quicker than that below, the water at the bottom freezes soonest. There seems to be something defective in this explanation; for, as far as we know, agitation can impede freezing or crystallization in no other way than by mixing the warmer parts of the fluid with the colder. But there is no doubt of the fact, from the concurring testimony of fishermen and other inhabitants near rivers, who are well acquainted with ground ice; besides which, M. Pott made an experiment in frosty weather with two similar tubs, into each of which were thrown nails, iron wire covered with flannel, hair, &c. A current of water was made to pass through one of them, and in the other was placed water with no current. Ice was formed on the nails and other substances at the bottom of the former, but none at the surface. And in the latter the surface was congealed, but there was no ice at the bottom. I am inclined to think that the formation of ground ice depends on the springs, which issue from the earth at a more elevated temperature than the freezing point; namely, at the medium temperature of the climate. Suppose a spring to issue from the earth at the temperature of 40° , into a freezing atmosphere, it naturally follows, and experience shews, that the stream must run over a certain extent of ground before it can be cooled as low as 32° , and become congealed. And if other springs flow into it from distances nearer their own sources, the distance of the place of congelation from the first source may be still more augmented. When the original stream has increased to the size of a river, the effect of the additional springs will be confined to the surface. Hales is mistaken in supposing that the water at the surface flows quickest, for all hydrostatical writers prove the contrary. Suppose now that the water be cooled as low as 32° , or lower, at a certain part of the river. It will there begin to freeze, and the larger masses will be accumulated where the crystallization is least disturbed, namely, at the edges. But the subsequent accessary streams will flow on the surface of this, because warmer, and consequently lighter; and as the lower part of a river runs the swiftest, it will
follow

follow that the stream, in the act of congelation, will flow on beneath the upper and warmer stream, and deposit ice upon the stones at the bottom, while none appears at the surface. If this explanation be true, it will be found, 1. That wherever ground ice is found, there will be ice at the surface, higher up the stream; and, 2. the river has received a supply from some warmer springs at some place intermediate between the places where the ice is formed at the surface, and where it is formed at the bottom.

The expansive force of water, when it is converted into ice, is greater than any strength in the texture of bodies which has been opposed to it. Boyle and Hales made the experiment with pistol-barrels and bomb-shells, which were bursten by the expansion. Other philosophers have since repeated these experiments with similar results.

The freezing point of water is the 32° on Fahrenheit's scale. See **HEAT**, **THERMOMETER**, **WATER**.

ICELAND SPAR. A substance which has greatly engaged the attention of philosophers, under this name, or the name of Iceland crystal. Bartholin, Huyghens, Newton, Beccaria, and others of later date, have made experiments on its remarkable property of separating the rays of light in such a manner as to exhibit two images of an object seen through it. It is the transparent specimen of common calcareous spar, and usually contains about 54 parts lime, 35 fixed air, and the rest water. Its specific gravity is about 2,7. Priestley's Optics, and the authors referred to by him, may be consulted, for an account of as much of the laws of this unusual refraction as is yet known. Magellan* says, that M. Fromond, professor of natural philosophy at Milan, has observed that glass has the same effect, whenever a number of parallel lines have been cut on its surface with a diamond, at the distance of the five hundredth or thousandth of an inch asunder; and that he (M.) had seen one of the pieces of glass which produced this effect. Hence it should seem as if the effect were produced either by inequalities at the surface, or fissures in the mass itself.

ICHTHYOCOLLA. Fish-glue, or *Isinglass*; which see.

IGNIS FATUUS. A luminous appearance or flame, frequently seen in the night in different country places, and called in England *Will-with-the-wisp*. It sometimes appears in the form of a flame dancing or undulating above the lower plants of the field; in other instances it has the appearance of an extensive luminous exhalation; sometimes it is seen to have a considerably rapid progressive motion; and other observations shew that it may have a stationary appearance, and definite form. Philosophers are not agreed as to its cause; but it appears probable that these meteors near the surface of the earth may not all be of the same nature. It seems with us to be mostly occasioned by the extrication of phosphorus from rotting leaves and other vegetable matters, which may be carried up in the first state of combustion by the summer heat, and rendered visible at night. Whether the inflammable air extricated from marshes may produce an appearance of this kind, is doubtful. It is probable that the motionless ignes fatui of Italy may be produced by the slow combustion of sulphur, emitted through clefts and apertures in the soil of that volcanic country.

ILLUMINATION. See **LIGHT**.

INCINERATION. The combustion of vegetable or animal substances, for the purpose of obtaining their ashes or fixed residue.

* On Cronstedt, i. 26.

INCOMBUSTIBLE CLOTH. See **ASBESTOS**.

INCRUSTATION. When the external part of any mineral is of a different texture and appearance from the internal part, the former is called the incrustation.

INDIGO. A blue colouring matter extracted from a plant called Anil, or the Indigo Plant. See **ANIL**.

In the preparation of this drug the herb is put into a vat or cistern, called the steeping trough, and there covered with water. The matter begins to ferment sooner or later, according to the warmth of the weather and the maturity of the plant; sometimes in six or eight hours, and sometimes in not less than twenty. The liquor grows hot, throws up a plentiful froth, thickens by degrees, and acquires a blue colour inclining to violet. At this time, without touching the herb, the liquor impregnated with its tincture is let out by cocks in the bottom into another vat placed for that purpose, so as to be commanded by the first. M. Quatremere says, that inflammable air is disengaged during this fermentation.

In the second vat, called the beating vat, the liquor is strongly and incessantly beaten with a kind of buckets fastened to poles, till the colouring matter is united into a body. Lewis*, from Labat, says, that much nicety is required to hit the point at which the colour is disposed to subside, because it is again taken up if the beating be too long continued; and that the manufacturers accordingly make frequent observations on small quantities of the liquid taken out in a cup. But this does not agree with the assertion of M. Le Blond†, who affirms that the effect of beating is to dissipate a quantity of fixed air, by which the blue fecula is suspended; that this method is insufficient to throw down the whole; but that the addition of lime water completely accomplishes it. It is said by Labat, that lime-water, or lime, is sometimes used in the beating; and he conjectures, that the hardness or flintiness of some indigo may be caused by this practice.

As soon as it is judged from the blue colour of the liquid that the beating is sufficient, it is left at rest for two hours; after which the clear liquor is drawn off by cocks in the side of the vat, and the blue part is discharged by another cock into a third vat, where it is suffered to settle for some time longer; then conveyed in a half fluid state into bags of cloth, to strain off more of its moisture; and lastly, exposed to the air in the shade in shallow wooden boxes, till it is thoroughly dry.

The indigo thus produced differs in its quality, not only according to that of the plant, but likewise the care taken in manufacturing it. Its colouring part appears nevertheless to be always the same, and its variations depend only on the admixture of foreign matter, and the consistence it acquires in drying.

Berthollet speaks of the indigo from Guatimala, as the best of any. It is so light as to swim on the surface of water instead of sinking to the bottom, as all the other kinds do. Another kind is called coppery indigo, because its surface acquires a copper colour when rubbed with a hard body: there are other kinds of less purity, such as that from Carolina.

Bergman examined this drug in his usual masterly way: he found that one ninth part of the indigo was taken up by boiling it in water. The parts dissolved were partly mucilaginous, partly astringent, and partly saponaceous. The

* On Neumann, ii. 237. † Berthollet on Dying, ii. 47. But vide infra, p. 398.

solution of alum, and of martial as well as cupreous vitriol, precipitate the astringent portion.

M. Quatremere likewise separated the soluble part of indigo by means of water. He pretends that the quantity thus taken up is more in proportion, as the indigo is of inferior quality; and affirms, that the indigo thus purified is equal to the best. Berthollet remarks upon this method of purifying, that though doubtless advantageous, it is not perfectly effectual, because it leaves the earthy insoluble parts, which, though not detrimental to the colour, must certainly affect the proportion of colouring matter.

Powder of indigo, digested in pure ardent spirit, afforded a tincture, first yellow, then red, and lastly brown. By several repetitions of this process it lost one twenty-seventh part of its weight. Water being added to the spirit, threw down a brownish resinous matter.

Ether had nearly the same action on indigo as the ardent spirit; but oils, whether fixed or volatile, affected it very little.

Bergman mixed one part of well pulverized indigo with eight parts of colourless vitriolic acid, of the specific gravity of 1,900, in a glass vessel slightly closed. The acid very quickly acted upon the indigo, and excited much heat. After a digestion of twenty-four hours the solution was effected; but the mixture was opaque and black. By the addition of water it became more transparent, exhibiting in succession all the shades of blue, according to the quantity of water added. At least twenty pounds of water were required to render the smallest drop of the solution imperceptible in a cylindric glass of seven inches diameter.

If the vitriolic acid be first diluted in the water, it attacks only the earthy principle which is mixed with the indigo, and some of the mucilaginous parts.

The fixed alkalis perfectly mild, that is, saturated with fixed air or aerial acid, separate a very fine blue powder from the solution of indigo, which is deposited very slowly. Bergman distinguishes this by the name of precipitated indigo. It is also obtained by pouring the solution drop by drop into ardent spirits, or into the saturated solutions of alum, of Glauber's salt, or of other salts containing the vitriolic acid. But the liquid always remains a little coloured.

The concentrated nitrous acid attacks indigo with so much activity as to set it on fire; but if the acid be properly diluted, it acts with less violence. The colour of the indigo becomes ferruginous, and the residue, which has the appearance of amber, amounts to no more than one third of the weight of the indigo. Fixed alkali precipitates from the acid a small quantity of calx of iron, mixed with the calcareous and ponderous earths. But if too much alkali be added, part of the precipitate is re-dissolved, and the colour of the fluid is rendered deeper than before.

Hauffman, in a very interesting dissertation*, has given a more connected set of observations on the changes produced in indigo by the pale nitrous acid. When the whole of the indigo he had exposed to the action of this acid had appeared to be destroyed, he found in the vessel a coagulum, which, after all the nitrous acid had been carried off by washing, formed a brown viscid mass of the appearance of a gum resin. It was soluble in pure ardent spirit, which indigo is not, and was not soluble in water, but when the quantity was great. It was more soluble in hot water than cold, and was considerably bitter. The water which had been used in the lotions, afforded by evaporation small crystals, which

* Quoted by Berthollet on Dying, ii. 34. It is found in the J. de Physique for March 1788.

exhibited several of the properties of the acids of tartar and of sorrel, but which were not precisely determined by the author.

The marine acid by digestion, and even boiling upon indigo, takes up the earthy matter, the iron, and a little of the extractive matter, which gives it a brown colour, but in no respect attacks the blue colour. If the indigo be precipitated from the vitriolic acid, the marine acid will very readily take up a certain quantity, and acquires a deep blue colour.

Other acids, such as those of tartar, of ants, of vinegar, and of phosphorus, have the same habitudes with indigo as the marine; that is, they do not attack it, but dissolve the precipitate very well. Vitriolic acid too much diluted to be capable of dissolving indigo, or nitrous acid, which from the same cause is too weak to act upon it, take up only the earthy and extractive parts, which are foreign to the colouring matter.

The dephlogisticated or aerated marine acid has scarcely any effect upon indigo in substance; but it destroys the colour of indigo in a state of solution. Berthollet applied it to the solution in vitriolic acid. By the admixture of the aerated marine acid the blue colour was entirely destroyed, and the fluid became of a yellow brown. He evaporated it in this state, and obtained by gradual deposition a viscid blackish matter, which appeared to be of the same nature as that afforded to Mr. Hauffman by the nitrous acid.

This effect of the aerated marine acid is considered by Berthollet, as affording a good method of ascertaining the proportional quantities of colouring matter in the different kinds of indigo. For this purpose he takes equal weights of each carefully powdered, and puts them into separate matrasses, with eight times their weight of concentrated vitriolic acid. These are to be kept for twenty-four hours in a heat between 100° and 120° of Fahrenheit, for which purpose a dung-hill, or the tan bed of an hot-house, may be employed. Each solution is then diluted with an equal quantity of water filtered, and the residue found on the filters collected, separately ground in a glass mortar, again digested with a little vitriolic acid, diluted with equal quantities of water, and each added to its corresponding liquor. And lastly, to each solution is added so much aerated marine acid as is necessary to discharge the colour, or rather to bring them all to the same shade of yellow. The goodness of each kind of indigo is proportionate to the quantity of aerated acid employed to destroy the colour.

Pure or caustic fixed alkali dissolves some matters foreign to the colouring matter of the indigo, but acts very little on the colouring particles. Pure volatile alkali has nearly the same effect. Precipitated indigo is speedily dissolved in the cold in the alkalis, whether fixed or volatile, if pure or caustic. The blue colour is gradually changed to a green, and at last destroyed. But mild alkalis do not alter the colour. Lime water has little action upon indigo; but it dissolves it when precipitated, and affects the colour nearly in the same manner as caustic alkalis do.

Indigo exposed to the action of fire in an open crucible, or under a muffle, smokes, swells up, ignites, and sometimes takes fire with a white flame. One hundred parts of indigo leave thirty-three or thirty-four parts of ashes. These do not afford fixed alkali when lixiviated with distilled water. Marine acid dissolves the greatest part of the ashes with a slight effervescence. The insoluble remainder is about one eleventh part, and has the characters of siliceous earth.

From

From this muriated solution the Prussian alkali throws down from thirty to thirty-two grains of the blue precipitate, which represents five or six of iron in the ounce. The ashes likewise contain the calcareous and ponderous earths, besides the iron and silex.

Indigo detonates strongly with nitre. By destructive distillation it affords fixed air, a liquor containing a little volatile alkali, and an oil resembling the empyreumatic oil of tobacco, and very soluble in ardent spirit.

Bergman concludes from his analysis, that one hundred parts of good indigo contain

Of mucilaginous matter separable by water	-	12
Resinous matter soluble in ardent spirit	-	6
Earthy matter taken up by the acetous acid, which does not attack the iron here in the state of calx		22
Calx of iron taken up by the marine acid	-	13

There remained forty-seven parts, which are the colouring matter, nearly in a state of purity; and afforded by distillation,

Fixable air	-	-	-	-	2
Alkaline liquor	-	-	-	-	8
Empyreumatic oil	-	-	-	-	9
Coal	-	-	-	-	23

The coal when burned in the open air afforded four parts of earth, of which nearly half was calx of iron, and the rest siliceous earth in a very subtle powder.

From these results Bergman concludes, that indigo is a substance analogous to Prussian blue and the colouring matter of ink; and that its colour, like those, is owing to iron. Upon this deduction Berthollet * remarks, with regard to Bergman's inference respecting the iron, that by an error in estimating the value of the Prussian blue, this great chemist has stated the quantity of this metal about four times too large; that the iron taken up by marine acid is extraneous to the pure indigo, as well as the earths, and the mucilage and resin taken up by water and ardent spirit. So that, on an accurate consideration of the facts, there does not appear to be more than one thirtieth part of iron in a combined state. He observes, that it is at present well known, that the products of destructive distillation, such as oil, carbonic acid, or fixed air, and volatile alkali, do not previously exist in bodies, but are afforded by new combinations of the principles which formed the body acted upon. And accordingly he concludes, that indigo contains a considerable quantity of hydrogen or inflammable air in a fixed state, a small quantity of azote or phlogisticated air, a very small portion of iron, and particularly a larger quantity of coal than is obtained from any other known vegetable substance. It does not appear whether the siliceous earth be merely an admixture, or whether it enter into the combination of the colouring matter.

From the great quantity of coal and inflammable air, he accounts for the combustibility of this substance, its detonation with nitre, and the effects of the nitrous and marine acids upon it. The fixity of its colour is also, in conformity to other observations of Berthollet, deduced from the quantity of coal, which is but slowly consumed by the action of vital air from the atmosphere. From a mature consideration of the process of the manufactory, this intelligent author

* Art of Dying, ii. 56.

deduces, that the indigo exists in the plant in a resinous state; that the kind of putrefaction it undergoes is of the nature of combustion, during which, part of its inflammable air is burned, and part flies off; and that the utility of the process of beating, is grounded on the facility it affords for the absorption of vital air. If the beating be continued too long, the indigo is rendered black, and becomes what is called burnt indigo.

The solubility of indigo in alkalis appears to be produced by the abstraction of part of the vital air it had absorbed, or, according to the ancient theory, by virtue of a process of phlogistication. This appears to be well established from the experiment of Bergman, wherein equal weights of martial vitriol and indigo, and double the weight of lime, are mixed together in water, and produce a solution of the indigo in the lime-water. But if the iron of the vitriol be previously calcined to a higher degree, by boiling it in much water for several hours, and subsequent evaporation, the solution will not be effected, because the precipitated iron is no longer disposed to absorb vital air, as the experiments of Priestley shew the common precipitate from vitriol to be. Or again, if indigo be added to a solution of caustic fixed alkali, and orpiment be added (which consists of arsenic and sulphur), the indigo is soon dissolved, and takes a green colour. If the arsenic corresponding with the orpiment be only added, the bath will never be fit for the dyer; but if the quantity of sulphur it ought to contain be added, the appearances of solution will speedily be had.

Mr. Hauffman proved by a direct experiment, that the solution of orpiment mixed with indigo is disposed to absorb vital air. For having placed this solution, which is known in the dye-houses by the name of printing blue, in contact with vital air expelled from nitre, seven-eighths of the air was absorbed, and the remainder was phlogisticated air. The blue solution was entirely spoiled. The indigo was regenerated. Some of the alkali formed vitriolated tartar with the acid; a portion of the alkali remained pure and uncombined; and the arsenic, instead of being in the metallic state as it is in the orpiment, was combined with it in the form of calx, or probably acidified.

It follows therefore, that indigo contains vital air in its natural state; that in this state it will not unite with lime or alkalis; but that substances capable of depriving it of part of its vital air, render it soluble in lime or alkalis; and lastly, that the natural state of the indigo is restored by the contact of vital air which it absorbs. In this last way it is that the blue dye is effected. The piece comes out of the vat of the same colour as the solution: viz. green; but becomes blue by exposure to the air. The alkali, or lime, is carried off by the washing, and the indigo remains combined with the stuff by this means dyed.

The action of acids, even the vitriolic, upon indigo, appears to affect it in the way of combustion; by which it is so far altered as not to adhere so strongly to wool or silk as when in its natural state. For other interesting particulars, consult the Memoir of M. Hauffman before cited, and compare with the Theories of Bergman and Berthollet.

INFERNAL STONE. Lapis infernalis. A name frequently given to the combination of silver with the nitrous acid, which is fused into little sticks to be used as a caustic.

INFLAMMABLE AIR. See AIR INFLAMMABLE.

INFLAMMABLE PRINCIPLE. See PHLOGISTICS.

INFLAMMATION of OILS. See ACID NITROUS.

INFUSION. The word infusion is used by chemists, to denote a quantity of water loaded with as much of the principles of any substance, not totally soluble, as it will take up in the usual temperature of the atmosphere.

INK. Every liquid or pigment used for writing or printing, is distinguished by the name of ink. Common practice knows only black and red.

Of black ink there are three principal kinds: 1. Indian ink, 2. printers' ink, and 3. writing ink.

The Indian ink is used in China for writing with a brush, and for painting upon the soft flexible paper of Chinese manufacture. It is ascertained as well from experiment as from information, that the cakes of this ink are made of lamp black and size, or animal glue, with the addition of perfumes or other substances not essential to its quality as an ink. It is used in Europe for designs in black and white, in which it possesses the advantage of affording various depths of shade, according to its state of dilution with water.

The general composition of printers' ink is well known, but the particulars of the process by which ink of the best quality is made are kept secret by the few manufacturers of this article. It is probable, that the demand is not sufficient to afford inducements for men of research to make many experiments on this object, and it is not unlikely that much may depend on minute circumstances in the management.

Good printers' ink is a black paint, smooth and uniform in its composition, of a firm black colour, and possesses a remarkable aptitude to adhere to paper thoroughly impregnated with moisture. It is remarkable, that this composition adheres uniformly to the wetted sheep-skin cover of the printers'-balls, which a common oil paint would not do; that it quits the wet ball to adhere to the face of the dry metallic type, and this so perfectly as to leave a new skin bare where the type touches it; and that much the greater part of the ink afterwards leaves the type to adhere to the moistened paper, but will not if the paper be dry. If the ink do not possess these requisites, it will not work well, but will clog the face of the letter, and give an imperfect impression.

The *consistence and tenacity of the oil in this composition are greatly increased, and its greasiness diminished, by means of fire. Linseed oil or nut oil is made choice of for this use. The nut oil is supposed to be the best, and is accordingly preferred for the black ink, though the darker colour it acquires from the fire renders it less fit for the red. It is said, that the other expressed oils cannot be sufficiently freed from their unctuous quality; whence the ink made with them dries exceeding slowly, is apt to come off and smear the paper in the beating and pressing it undergoes in the hands of the bookbinder, or sinks into the substance of the paper beyond the mark of the type, and stains it yellow.

Ten or twelve gallons of the oil are set over the fire in an iron pot, capable of holding at least half as much more; for the oil swells up greatly, and its boiling over into the fire would be very dangerous. When it boils it is kept stirring with an iron ladle; and if it do not itself take fire, it is kindled with a piece of flaming paper or wood; for simple boiling, without the actual accension of the oil, does not communicate a sufficient degree of the drying quality required. The oil is suffered to burn for half an hour or more, and the flame being then extinguished by covering the vessel close, the boiling is afterwards continued with a gentle heat, till the oil appears of a proper consistence: in which state it

* Lewis's Philosophical Commerce of Arts.

is called varnish. It is necessary to have two kinds of this varnish, a thicker and a thinner, from the greater or lesser boiling, to be occasionally mixed together, as different purposes may require; that which answers well in hot weather being too thick in cold, and large characters not requiring so stiff an ink as small ones.

The thickest varnish when cold may be drawn into threads like weak glue; by which criterion the workmen judge of the due boiling, small quantities being from time to time taken out and dropped upon a tile for this purpose. It is very viscid and tenacious, like the soft resinous juices or thick turpentine. Neither water nor ardent spirit dissolves it; but it readily enough mingles with fresh oil, and unites with mucilages into a mass diffusible in water in an emulsive form. Boiling with caustic alkali produces a soapy compound. It is by washing with hot soap-lees and a brush that the printers clean their types. The oil loses from one-tenth to one-eighth of its weight by the boiling into the thick varnish. This loss seems to differ in different samples of the same kind of oil. Dr. Lewis found that fish oil lost three-fourths of its weight by this treatment, before it acquired the thickness produced in linseed oil.

The workmen are accustomed to add in the preparation of ten or twelve gallons of oil, as soon as the burning is over, a pound or two of dry crusts of bread, and a dozen or two of onions, by which they suppose the greasiness to be more effectually destroyed. Dr. Lewis, with much appearance of justice, doubts the advantage of such additions, and that more especially, as he prepared the varnish seemingly of a good quality by the fire alone. There are other additions of more evident effect, namely, turpentine or litharge, both which are occasionally used. The turpentine is boiled first by itself to a state nearly of resin, and the oil being taken from the fire, the hot fluid turpentine is poured in, and the boiling then continued to the proper point. This is somewhat difficult to attain, because the mixture is more disposed to grow too thick if over-boiled; and is full of little hard grains, probably of resin, if not sufficiently boiled. It is affirmed that varnish containing either turpentine or litharge, particularly the latter, is more adhesive than other varnish, and presents a great difficulty in cleaning the types, which soon become clogged. Very old oil requires neither of these additions. New oil can hardly be brought into a proper state for drying, so as not to set off, without the use of turpentine.

Lamp black is the common material to give the black colour, of which two ounces and a half are sufficient for sixteen ounces of the varnish. Vermilion is a good red. They are ground together on a stone with a muller, in the same manner as oil paints.

The ink used by copper-plate printers differs in the oil, which is not so much boiled as to acquire the adhesive quality. This would render it less disposed to enter the cavities of the engraving, and more difficult either to be spread or wiped off. The black is likewise of a different kind. Instead of lamp black or sublimed charcoal, the Frankfort black is used, which is a residual or denser charcoal, said to be made from vine-twigs. This is softer and less gritty than the ivory or other blacks prepared among us, and no doubt contains more coal than any animal residue, as all these abound with phosphorated lime. It is said that lamp black gives always a degree of toughness to the ink, which the Frankfort black does not; but the goodness of the colour seems to be the leading inducement for the use of the latter. A pale or brown black can be much more easily endured in a book than in the impression of an engraving.

We have no good explanation of what happens with regard to the chemical effect of boiling and burning upon the oil for printers' use.

Common ink for writing is made by adding an infusion or decoction of the nut gall to martial vitriol, dissolved in water. A very fine black precipitate is thrown down, the speedy subsidence of which is prevented by the addition of a proper quantity of gum arabic. This is usually accounted for by the superior affinity of the acid of galls, which combining with the iron, takes it from the vitriolic acid, and falls down. But it appears as if this were not the simple state of the facts; for the vitriolic acid in ink is not so far disengaged as to act speedily upon fresh iron, or give other manifestations of its presence in an uncombined state.

M. Ribaucourt * has paid particular attention to the process for making black ink. In his experiments the dark coloured rough galls, called Aleppo galls, were used, which are the best.

He poured a solution of mild vegetable alkali (potasse) upon a strong decoction of three ounces of galls, which precipitated nine drams of a grey earth soluble with effervescence in acids. The supernatant fluid was turbid, but the addition of a small quantity of the alkali threw down a little brown matter, after which the liquor became of a fine clear green. This liquid being evaporated to dryness and calcined, afforded a very white vitriolated tartar by lixiviation.

Hence he concludes that the nut gall, besides the colouring matter, contains three drams per ounce of calcareous earth, with a portion of vitriolic acid, but that the vitriolic acid not being sufficient to saturate the earth, the remaining portion was originally suspended by the astringent principle, or acid of galls.

In the next place he poured a solution of one pound of martial vitriol into a strong decoction of one pound of nut galls. He diluted the mixture with so much water, as in the whole made forty pounds, and left the mixture at rest.

At the end of twenty-four hours the liquid was coloured of a very deep blackish purple. Upon decantation, there was found at the bottom of the vessel a very coarse precipitate, harsh to the touch, which being collected on the filter and dried, was of a greyish blue colour, very compact, brittle, and shining in its fracture. Its weight was † eleven ounces and a half.

Forty pounds of water were poured to the decanted fluid, which was again left at rest for twenty-four hours. Its colour was then found to be much feebler. A new deposition had been made, which was separated as before and dried. It was of a purplish blue, rare and friable between the fingers, granulated and dull in its fracture. Its weight was four ounces two drams.

Forty pounds more of water were added to the decanted liquor, and after twenty-four hours subsidence it was perfectly discoloured, and exhibited no sign of the presence of iron, either by the agency of nut galls, or Prussian acid; nor of earth by the addition of an alkali. The precipitate which had subsided was light, rare, of a blue less purple and more black than the second precipitate; softer to the touch while wet, and lighter and more friable when dry. It weighed two ounces two drams.

* Annales de Chimie, xv. 113.

† I translate *livres*, *onces*, and *gros*, by pounds, ounces, and drams. For though the Paris pound is to our Avoirdupois pound, as 7560 to 7000, the number of grains in each, yet the subdivision being numerically the same, the results will not be altered by omitting the reduction.

These additional precipitates, obtained by means of dilution with water, would have been very embarrassing to M. de Ribaucourt, if he had not before experienced a similar decomposition of alum, which he says deposits its earth entirely by the addition of one hundred and ninety-five parts of water. By a direct experiment he found, that six hundred and eighty-one parts of water decompose one of vitriol of iron.

From these facts he infers, that the calcareous earth of the galls unites with the vitriolic acid of the vitriol, and forms selenite, most of which falls down with the first precipitate, on account of its insolubility in water; while the calx of iron combines with the colouring matter of the galls, and forms the black fecula which subsides more slowly.

The blue colour of the three precipitates obtained in the first set of experiments, naturally directed M. R.'s attention to the theory of Prussian blue; and that the more especially, as these precipitates were acted upon with difficulty by acids. This action has indeed been considered as a proof that the colouring matter is not the same in Prussian blue, which is insoluble in acids, and the coloured iron in ink, which is taken up, though slowly. But M. Ribaucourt had recourse to the common process of combining the colouring matter with an alkali.

The first of the three precipitates placed over a gentle fire, with an alkaline solution (mild I suppose), shewed a considerable effervescence as soon as the fluid became warm. This he ascribes to the decomposition of the selenite, which must have expelled fixed air from the alkali. The fluid assumed a reddish colour.

The second precipitate, treated in the same manner, shewed scarcely any effervescence, and the colour of the fluid was deeper.

The third did not effervesce, and the colour was nearly the same as the preceding.

Each of these solutions, after filtration and dilution with water, afforded Prussian blue, by the addition of vitriol of iron.

Logwood was found to be an useful ingredient in ink, because its colouring matter is disposed to unite with the calx of iron, and renders it not only of a very dark colour, but less capable of change from the action of acids, or of the air.

Vitriol of copper in a certain proportion was found to give depth and firmness to the colour of the ink. Gum arabic, or other pure gums, was of service, by retarding the precipitation of the fecula; by preventing the ink from spreading or sinking into the paper, and by affording it a kind of compact varnish, or defence from the air, when dry. Sugar appeared to have some bad qualities, but was of use in giving a degree of fluidity to the ink, which permitted the dose of gum to be enlarged beyond what the ink would bear without it. Water proved to be the best solvent.

Lewis* had supposed that the defects of ink arise chiefly from a want of colouring matter. But the theory, grounded on the facts discovered by M. Ribaucourt, requires that none of the principles should be in excess. If there be a want of the matter of the galls, part of the vitriol will not be decomposed; if, on the contrary, there be too much, the vitriol will take as much as it can decompose, and the remainder will be nearly in the state of the decoction of galls, subject to change by becoming mouldy, or to undergo an alteration after writing,

* Philosoph. Commerce of Arts.

which destroys its legibility much more completely than the change undergone by ink containing too small a proportion of the galls.

It is doubtful whether the principles of the galls are well extracted by cold maceration; and it is certain that inks made in this way flow pale from the pen, and are not of so deep a black as those wherein strong boiling is resorted to.

From all the foregoing considerations Mr. R. gives these directions for the composition of good ink:

Take eight ounces of Aleppo galls (in coarse powder); four ounces of logwood (in thin chips); four ounces of vitriol of iron; three ounces of gum arabic (in powder); one ounce of * vitriol of copper, and one ounce of sugar candy. Boil the galls and logwood together in twelve pounds of water for one hour, or till half the liquid has evaporated. Strain the decoction through an hair sieve, or linen cloth, and then add the other ingredients. Stir the mixture till the whole is dissolved, more especially the gum; after which leave it to subside for twenty-four hours. Then decant the ink, and preserve it in bottles of glass or stone ware, well corked.

On the subject of this memoir of M. Ribaucourt I must remark, that though it is highly valuable for the interesting facts it contains, and others to which it points, yet the chemical reader will be in a certain degree dissatisfied with the loose narrative form in which he gives some of his results, instead of the close and orderly method of the German chemists. The nature of the earth thrown down by an alkali from the decoctions of galls, that of the salt obtained by lixiviation of the supernatant fluid; whether the precipitate from alum by mere water was pure argillaceous earth, or only embryon alum; whether the Prussian blue thrown down from his alkali, after digestion with the atramentous precipitate, stood the usual tests, &c. these and other questions present themselves for resolution from facts, which the ingenious author has omitted fully to state; and from this uncertainty we are disposed rather to invite the philosophical chemist to repeat and extend this important series of experiments, than to rely implicitly upon them.

Dr. Lewis uses vinegar for his menstruum; and M. Ribaucourt has vitriol of copper among his ingredients. I have found an inconvenience from the use of either, which, though it does not relate to the goodness of the ink, is sufficiently great, in their practical exhibition, to forbid their use. The acid of the vinegar acts so strongly upon the pen, that it very frequently requires mending; and the vitriol of copper has a still more unpleasant effect on the penknife. It seldom happens when a pen requires mending that the ink is wiped very perfectly from it; and often when the nib only is to be taken off, it is done without wiping at all. Whenever this is the case, the ink immediately deposits a film of copper upon the knife, and by superior elective attraction of the vitriolic acid, a corresponding portion of the edge of the knife is dissolved, and is by this means rendered incapable of cutting till it has been again set upon the hone.

Inks of other colours may be made from a strong decoction of the ingredients used in dying, mixed with a little alum and gum arabic. For example, a strong decoction of Brazil wood, with as much alum as it can dissolve, and a little gum, forms a good red ink. These processes consist in forming a lake, and retarding its precipitation by the gum. See **LAKE**.

* See the objection in the next paragraph but one.

Among the amusing experiments of the art of chemistry, the exhibition of sympathetic inks holds a distinguished place. With these the writing is invisible, until some reagent gives it opacity. We shall here mention a few out of the great number, that a slight acquaintance with chemistry may suggest to the student. 1. If a weak solution of galls be used, the writing will be invisible till the paper be moistened with a weak solution of vitriol of iron. It then becomes black, because these ingredients form ink. 2. If paper be soaked in a weak solution of galls, and dried, a pen dipped in the solution of vitriol will write black on that paper, but colourless on any other paper. 3. The diluted solutions of gold, silver, or mercury, remain colourless upon the paper, till exposed to the sun's light, which gives a dark colour to the calxes, and renders them visible. 4. Most of the acids or saline solutions being diluted, and used to write with, become visible by heating before the fire, which concentrates them, and assists their action on the paper. 5. Diluted Prussian alkali affords blue letters when wetted with the solution of martial vitriol. 6. The solution of cobalt in aqua regia, when diluted, affords an ink which becomes green when held to the fire, but disappears again when suffered to cool. This has been used in fanciful drawings of trees, whose green leaves appeared when warm, and vanished again by cold. This effect has not been explained. If the heat be continued too long after the letters appear, it renders them permanent.

Sympathetic inks have been proposed as the instruments of secret correspondence. But they are of little use in this respect, because the properties change by a few days remaining on the paper; most of them have more or less of a tinge when thoroughly dry; and none of them resist the test of heating the paper till it begins to be scorched.

INSECTS. Various important products are obtained from insects. The chief are, 1. CANTHARIDES. 2. MILLIPEDES. 3. COCHENILLE, or COCHINEAL. 4. KERMES. 5. LAC. 6. SILK. 7. WAX. For all which the several titles may be consulted.

INSTRUMENTS, CHEMICAL. See BALANCE, THERMOMETER, APPARATUS, LABORATORY.

INTERMEDIUM, or MEDIUM. When two chemical principles, which are not disposed to unite, are made to enter into a triple compound, by the addition of a third, this last is frequently called the medium, or intermedium. Thus fat oils are made to unite with water by the intermedium of a pure alkali, which converts the oil into soap.

IRON. Is a metal of a blueish white colour, of considerable hardness and elasticity; very malleable, exceedingly tenacious and ductile, and of a moderate specific gravity among metallic substances. It is much disposed to rust by the access of air, or the action of water, in the common temperature of the atmosphere. The appearance of prismatic colours on its polished surface takes place long before ignition; and at so low a temperature, that the slightest coating of grease is sufficient to prevent their appearance by defending it from the contact of air. It may be ignited, or at least rendered sufficiently hot to set fire to brimstone, by a quick succession of blows with a hammer. When struck with a flint, or other hard stone, it emits decrepitating ignited particles, such as can be obtained from no other metal by the same means. These particles are seldom larger than the two hundredth part of an inch in diameter; and when examined by a magnifier, are found to be hollow, brittle, and of a greyish colour, resembling the scales of burned iron. This metal is easily calcined by fire. A piece
of

of iron wire, immersed in a jar of vital air, being ignited at one end, will be entirely consumed by the successive combustion of its parts. It requires a most intense heat to fuse it; on which account it can only be brought into the shape of tools and utensils by hammering. This high degree of infusibility would deprive it of the most valuable property of metals, namely, the uniting of smaller masses into one, if it did not possess another singular and advantageous property, which is found in no other metal except platina; namely, that of welding. In a white heat, iron appears as if covered with a kind of varnish; and in this state, if two pieces be applied together, they will adhere, and may be perfectly united by forging. Iron is thought to be the only substance in nature which has the property of becoming magnetical. It is highly probable, from the great abundance of this metal, that all substances which exhibit magnetism do contain iron; but it must be confessed that there remain many experiments to be made among the earths and powders which exhibit magnetical properties, before this negative proposition, which confines magnetism to iron, can be admitted as proved.

When iron is exposed to the action of pure water, it acquires weight by gradual calcination, and inflammable air escapes: this is a very slow operation. But if the steam of water be made to pass through a red-hot gun barrel, or through an ignited copper or glass tube, containing iron wire, the iron becomes converted into a calx; while inflammable air passes out at the other end of the barrel. This capital experiment * may be accounted for according to the ancient and modern theories. In the ancient theory, it is supposed that the water has combined with the iron, and disengaged its phlogiston in the form of inflammable air; and consequently that, when this calx is again revived by heating a portion of it in inflammable air with a burning glass, and water appears, at the same time that part of the inflammable air is absorbed, the iron has imbibed phlogiston, and given out its water. Clear as this explanation appears to be, the solution afforded by the modern theory is not less perspicuous. The maintainers of this theory reason as follows: Iron has not been shewn to be a compound substance; let us therefore consider it as a simple substance, until we possess experiments which shew the contrary. Water has been shewn to be a compound substance, by the experiment of its production, by burning dephlogisticated and inflammable air together. We may fairly therefore affirm, that the inflammable air came from the water, in which we know it to exist; and that the vital air of the water, the peculiar instrument of calcination, has combined with the iron. On the other hand, when the iron is revived in inflammable air, the water which appears is the very product of combination which was decomposed in the former instance. For the vital air quits the iron to unite in the fluid state with the inflammable air; and the iron being set at liberty, recovers its original state; that is to say, it is revived.

That the iron, in the one instance, attracts vital air from the water, and disengages inflammable air; and, in the other instance, exhibits a less affinity with that substance, so as to restore it to its former combination; is a difficulty which, in the present state of our information, can only be accounted for by supposing that the temperature in the furnace differs from that produced by the burning glass; and that these affinities, like most others in chemistry, are not the same at all temperatures. This difficulty affects both theories alike; for it is not easier

* Of M. Lavoisier.

to account for the contrary transitions of water and phlogiston, which mutually expel each other in the old theory, than for the transitions of dephlogisticated and inflammable air in the new theory.

The philosophers who reject phlogiston insist, moreover, that the weight of the inflammable air produced, being deducted from the weight of the water made use of, leaves a quantity equal to the increase the iron gains by calcination; and that by burning the whole inflammable air produced, with a quantity of vital air equal in weight to the gain of the iron, a new quantity of water is recomposed, which is equal likewise to that made use of. Hence they urge, that it is infinitely more probable that the inflammable air came from the water than from the iron. The latter fact, of the recomposition, is in their favour; but the former is not. For whatever the inflammable air comes from, the first equation will be true; that is to say, if the iron give out phlogiston, and receive water, its accession of weight will be equal to the difference between the water it has received, and the phlogiston it has lost; but the reproduction of the water lost will then the inflammable air really corresponds with the quantity required to form* so much water, if we admit the accuracy of the experiments.

The concentrated vitriolic acid scarcely acts on iron, unless it be boiling. When the acid is distilled to dryness from this metal, the retort is found to contain sublimed flowers of sulphur, and a white vitriolic mass, partly soluble in water: the product which comes over is volatile vitriolic acid, and vitriolic acid air. If the vitriolic acid be diluted with two or three parts of water, it dissolves iron readily, without the assistance of any other heat than is produced by the act of combination. During this solution, inflammable air escapes in large quantities. If heat be applied, the acid proceeds to dissolve more iron, and deposits a white saline mass, or pale vitriol of iron.

The combination of vitriolic acid and iron, called martial vitriol, is much more soluble in hot than cold water; and therefore crystallizes by cooling, as well as by evaporation. The crystals are efflorescent, and fall into a white powder by exposure to a dry air, the iron becoming more calcined than before. A solution of martial vitriol, exposed to the air, imbibes its vital part; and a portion of the iron, becoming too much calcined to adhere to the acid, falls to the bottom in the form of ochre. The solution, as well as the crystals it affords by evaporation, are thus rendered paler than before.

Martial vitriol is not made in the direct way, because it can be obtained at less charge from the decomposition of martial pyrites.

The different appearances which accompany the solutions of iron in the vitriolic acid, may be accounted for according to the principles either of the ancient or modern theories. In the ancient theory, the iron, being supposed to contain phlogiston or the principle of inflammability, is calcined in both cases; that is

* It may be urged that the two airs contain much water; and for that, as well as other reasons, their absolute quantities cannot be ascertained. But it is not required to ascertain their absolute quantities: for it is enough if the two airs in this recomposition be exactly in the same state as in the original experiment, by which the component parts of water were determined. If a certain portion of water be necessary to inflammable air in the elastic state, it must of course take it from the steam in the gun-barrel at the instant of its extrication, and not afterwards from the water of the receivers: this requires to be confirmed by an experiment over mercury. How far Dr. Priestley's experiments (Phil. Trans. lxxviii and lxxix) may affect the position, that water is a compound substance, cannot be clearly ascertained until it is shewn that the acid produced in burning the two airs does not arise from impurity in one or both of them.

to say, it gives out phlogiston*. With the concentrated acid the solution does not take place; because the capacity of the mixture for heat, and consequently its absolute quantity of heat, is too small to supply what the increased capacity of the vitriolic acid air would require, and consequently the iron is not decomposed. But when heat is applied, the phlogiston of the iron uniting with the basis of part of the acid, forms sulphur; which, together with another portion of the acid, rises in the form of vitriolic acid air; at the same time that the vital air of the decomposed acid unites with the calx of iron, which becomes soluble in the acid that remains; but when much water is present, as in the diluted acid, the heat is supplied from the great capacity of the water; the phlogiston of the iron assumes the elastic form; and inflammable air flies off, while the acid unites with the calx of iron, and forms vitriol. The decomposition of the acid in the former, and not in the latter case, is accounted for from its strong attraction to the water. A considerable heat, applied with the diluted acid, calcines the iron more perfectly; which then either enters into the composition of pale vitriol, containing a larger proportion of acid, or falls down in the form of calx. The access of air does the same thing more gradually.

In the antiphlogistic theory, iron is assumed to be a simple substance; vitriolic acid is said to be composed of vital air and sulphur; and water is admitted to be decomposable. When iron therefore is applied to concentrated vitriolic acid, the principles retain their order of combination at a common temperature; but as soon as the temperature is raised, the iron becomes calcined, by attracting vital air from part of the acid, whose sulphur is therefore set at liberty, and flies off with another portion of the acid, in the form of vitriolic air; while the remaining acid combines with part of the calx. But when the acid is more diluted, the water itself is decomposed; its inflammable air is disengaged; its vital air unites with, and calcines the iron; and the vitriolic acid dissolves the calx.

The necessity of heat being applied to the concentrated solution in the one case rather than the other, may be referred to the capacities of the bodies before and after the change, in either theory. But it must be confessed, that the cause of the disengagement of vitriolic air in the one case, and inflammable in the other, is not so well solved. It has not been explained, upon the old theory, why the phlogiston in one case unites with the acid, and forms sulphur, and in the other flies off alone; neither has it been shewn, in the new theory, why the water should not be decomposed in the former instance, as well as the latter.

The further calcination of the iron by heat, or by exposure of the solution to the air, is accounted for, in the new theory, from the absorption of more vital air. The general fact, that a definite degree of calcination is necessary for the most perfect solution of metals in acids, depends on attractions which have not been experimentally resolved; but which, in the way of conjecture, may be as easily accounted for by one theory as by the other.

Vitriol of iron is decomposed by alkalis and by lime. Caustic fixed alkali precipitates the iron in deep green floes, which are dissolved by the addition of more alkali, and form a red tincture. The mild alkali does not re-dissolve the precipitate it throws down, which is of a greenish white colour. Dis-

* Kirwan, in *Philos. Transact.* vol. lxxii; and *Essay on Phlogiston*, London, 1789, page 62, or page 28 of the old edition.

tillation separates the acid from martial vitriol, and leaves the brown calx of iron, called colcothar.

Vegetable astrigent matters, such as nut-galls, the husks of nuts, logwood, tea, &c. which contain the acid of galls hereafter to be described, precipitate a fine black fecula from martial vitriol, which remains suspended for a considerable time in the fluid, by the addition of gum arabic. This fluid is well known by the name of ink. See **INK**.

The beautiful pigment, well known in the arts by the name of Prussian blue, is likewise a precipitate afforded by martial vitriol. See **BLUE PRUSSIAN**; also **ACID OF PRUSSIAN BLUE**.

Concentrated nitrous acid acts very strongly upon iron filings, much nitrous air being disengaged at the same time. The solution is of a reddish brown, and deposits the calx of iron after a certain time; more especially if the vessel be left exposed to the air. A diluted nitrous acid affords a more permanent solution of iron, of a greenish colour, or sometimes of a yellow colour; neither of the solutions affords crystals; but both deposit the calx of iron by boiling, at the same time that the fluid assumes a gelatinous appearance. This magma, by distillation, affords fuming nitrous acid, much nitrous air, and some phlogisticated air; a red calx being left behind, which, in all probability, retains most of the vital air of the acid.

If vegetable alkali be added to the nitrous solution of iron, a brown precipitate falls down; of which a small quantity is redissolved by the alkali. Mild vegetable alkali separates a yellowish calx, which soon becomes of a beautiful orange red colour. If the mixture be agitated during the effervescence, the precipitate is re-dissolved in much greater quantity than by the pure vegetable alkali; doubtless by the medium of the fixed air. This solution is known by the name of Stahl's martial alkaline tincture, and is of a fine red colour, which however is impaired by time. Pure volatile alkali separates a deep green and almost black precipitate from the nitrous solution of iron. The mild volatile alkali re-dissolves the iron, which it separates from the acid; and forms an alkaline tincture of a more lively colour than that of Stahl.

Diluted marine acid rapidly dissolves iron, at the same time that a large quantity of inflammable air is disengaged, and the mixture becomes hot. In this, as well as in the vitriolic solution of iron, the same quantity of alkali is said to be required to saturate the acid as before the solution; whence it is inferred, that the acid is not decomposed, but that the calcination is effected by the vital air of the water; whence also it appears to follow, that the inflammable air must be afforded from the decomposed water, and not from the metal. It must however be remarked, that this fact, as well as most of those upon which the rejection of phlogiston, or the inflammable principle, is grounded, are controverted by the philosophers who maintain the existence of that principle.

The marine solution of iron is of a yellowish green colour, and is much more permanent than the solutions of that metal in the vitriolic or nitrous acids; though, like all the other solutions of iron, it deposits its metal by exposure to the air. By evaporation it assumes the consistence of syrup; in which, needle-formed and deliquescent crystals appear. Some chemists affirm, that the acid quits the iron by distillation, though much more difficultly than either the nitrous or vitriolic acid; but this interesting experiment has not been made since the improvements of chemistry have led philosophers to attend to such products as appear in the permanently elastic state.

The marine solution of iron is decomposed by lime and by alkalis; but the precipitates are more easily reduced to the metallic state than those afforded by other acids. Liver of sulphur, hepatic air, and astringents, decompose this, as well as the other solutions of iron; and the pure Prussian alkali throws down a very fine blue precipitate.

Fixed air, dissolved in water, combines with a considerable quantity of iron, in proportion to its mass. Vinegar scarcely dissolves it, unless by the assistance of the air.

In the dry way, this metal does not combine with earths, unless it be previously calcined; in which case it assists their fusion, and imparts a green colour to the glass. It appears to combine with alkalis by fusion. Nitre detonates strongly with it, and becomes alkalized. Sal ammoniac is decomposed by it. Two parts of iron filings, triturated with one part of sal ammoniac, and exposed to distillation, afford about one part of liquid volatile alkali, contaminated by a small portion of iron. Some inflammable air comes over in this distillation, either from the iron or from the water contained in the sal ammoniac; the residue consists of iron, united to marine acid. A medical preparation is made by subliming sal ammoniac from a small portion of iron filings; which gives part of the salt a yellow colour. The calx of iron decomposes sal ammoniac by seizing its acid, even in the cold.

Sulphur combines very readily with iron, in the dry and even in the humid way, though neither of these substances is scarcely at all soluble in water. A mixture of iron filings and flowers of sulphur being moistened, or made into a paste, with water, becomes hot, swells, adheres together, breaks, and emits watery vapours of an hepatic smell. If the mixture be considerable in quantity, as for example, one hundred pounds, it takes fire in twenty or thirty hours, as soon as the aqueous vapours cease. This effect may be explained without difficulty in a general way, though the circumstances require to be more minutely examined:—Iron, sulphur and water, are placed in contact. The iron is very sparingly soluble in water*; and the sulphur is probably soluble in a small degree, as may be judged by its becoming soft in that fluid. In the ancient theory, it may be said that the sulphur combines with the calx of the iron, and expels its inflammable air or phlogiston. The heat must be deduced, in any theory, from the change of capacity, or rapid commotion, produced in the act of union. This heat volatilizes part of the sulphur, together with the inflammable air; and if the temperature be sufficiently elevated, these substances will take fire, at the moment of their extrication, by the assistance of the air of the atmosphere. In the new theory, the explanation will be nearly the same. The iron and the sulphur, being considered as simple substances, tend to combine with each other, through the medium of vital air, which calcines the iron, and is supposed to be afforded by decomposition of the water. The same decomposition extricates inflammable air from the water. This, together with the sulphur, forms hepatic air; which flying off at the temperature of ignition, takes fire by combination with the air of the atmosphere. In this theory it may further be added, that, as sulphur and water, in contact, at an elevated temperature, afford inflammable air, which is explained by the supposition of vital air combining with the sulphur, there would be an increase of inflammation from this cause. Some doubt however may be entertained, whether sulphur be more combustible

* Annales de Chimie, vol. i. 220.

than inflammable air at any temperature, since hepatic air deposits sulphur when detonated with vital air; which must, in all probability, depend on the latter being less combustible at the temperature of inflammation. On the whole, it appears, that facts and observations are wanting, rather than probable theories; and that it is scarcely necessary to pursue this inquiry more minutely in the way of argumentative disquisition. The spontaneous combustion of iron and sulphur with water, is evidently an effect of the same kind as the decomposition of pyrites.

Sulphur combines very readily with iron by fusion; and produces a compound of the same nature as the pyrites, and exhibiting the same radiated structure when broken. If a bar of iron be heated to whiteness, and then touched with a roll of sulphur, the two substances combine, and drop down together in a fluid state. It is necessary that this experiment should be made in a place where there is a current of air to carry off the fumes; and the melted matter, which may be received in a vessel of water, is of the same nature as that produced by fusion in the common way, excepting that a greater quantity of sulphur is fused by the contact of the bar of iron. The experiment of combining iron and sulphur together by fusion, has not been made with an attention to the volatile products, if any be extricated. As neither of these substances contains water, and both are supposed, in the new theory, to be simple bodies, the experiment might, perhaps, afford an interesting result.

If equal parts of phosphoric glass, and iron clippings, together with one-sixteenth of a part of pulverized charcoal, be fused together, the mixture is very brittle, white in its fracture, and of a striated and granulated texture. This combination of iron with phosphoric acid is found in the iron produced from bog ores, which abound in the remains of decayed vegetables. It is the cause of brittleness in the iron when cold, which occasions that kind of iron to be called cold short iron by the workmen. Phosphorated iron was at first taken to be a peculiar metal, and was called *silerite* by Bergman.

Iron unites with gold, silver, and platina. When heated to a white heat, and plunged in mercury, it becomes covered with a coating of that metal. Long trituration of mercurial amalgams likewise causes a coating to adhere to the ends of iron pestles; small steel springs, kept plunged beneath the surface of mercury in certain barometers, become brittle in process of time; and the direct combination of iron and mercury in the form of an amalgam, may be obtained by triturating the filings with twice their weight of alum, then adding an equal weight or more of mercury, and continuing the friction, with a very small quantity of water, till the union is completed. Iron and tin very readily unite together, as is seen in the art of tinning iron vessels, and in the fabrication of those useful plates of iron, coated with tin, which are generally distinguished by the simple name of tin alone. The chief art of applying those coatings of tin, consists in defending the metals from calcination by the access of air. After the iron plates are scraped, or rendered very clean by scouring with an acid, they are wetted with a solution of sal ammoniac, and plunged into a vessel containing melted tin, the surface of which is covered with pitch or tallow, to preserve it from calcination. The tin adheres to, and intimately combines with the iron to a certain depth, which renders the tinned plates less disposed to harden by hammering, than before, as well as much less disposed to alter, by the united action

* Vogell in Crell's Annals, ii. 103. Eng. trans.

of air and moisture. The process for tinning of iron vessels does not essentially differ from that which has already been described of copper vessels. Iron does not unite with bismuth, at least in the direct way. As nickel cannot be purified from iron without the greatest difficulty, it may be presumed that these substances would readily unite, if the extreme infusibility of both did not present an obstacle to the chemical operator. Arsenic forms a brittle substance in its combination with iron. This semi-metal, which is so abundant in the mineral kingdom, is said to be the cause of the brittleness, which some specimens of iron possess when hot, though malleable when cold. Iron thus contaminated, is distinguished by workmen, by the name of red short iron. Cobalt forms a hard mixture with iron, which is not easily broken. The inflammability and volatility of zinc present an obstacle to its combination with iron. It is not improbable, however, but that clean iron filings would unite with zinc, if that metal were kept in contact with them for a certain time, in a heat not sufficient to cause it to rise; for it has been found that zinc may be used in the operation of coating iron in the same manner as tin. Antimony unites with iron, and forms a hard brittle combination, which yields in a slight degree to the hammer. The combination of sulphur and the regulus of antimony, which is commonly known by the name of antimony, is decomposed by virtue of the greater affinity of the iron to the sulphur. For this purpose, five ounces of the points of nails from the farriers may be made red hot in a crucible, one pound of pulverized ore of antimony must then be thrown into the crucible, and the heat quickly raised to fuse the whole. When the fusion is perfect, an ounce of nitre in powder may be thrown in, to facilitate the separation of the scoriæ. After the mass is cooled, the antimony is found separate at the bottom of the crucible, while the iron remains in combination with the sulphur and alkali. If the proportion of the iron be considerably greater than five ounces to the pound of antimonial mineral, the regulus will be alloyed with iron. Manganese is almost always united with iron in the native state. Wolfram forms a brittle whitish-brown hard alloy, of a compact texture, when fused with white crude iron.

The habitudes of iron with the regulus of molybdena are not known.

Iron is the most diffused, and most abundant, of metallic substances. Few mineral bodies, or stones, are without an admixture of this metal. Sands, clays, and the waters of rivers, springs, rain, or snow, are scarcely ever perfectly free from it. The parts of animal and vegetable substances likewise afford iron in the residues they leave after incineration. It has been found native, in large masses, in Siberia*, and in the internal parts of South America. This metal however in its native state is scarce: most iron is found in the calciform state, in ochres, bog ores, and other friable earthy substances, of a red, brown, yellow, or black colour. The hamatites, or blood stones, are likewise calciform ores of iron: these are either of a red colour, or blue, yellow, or brown. This useful metal is so abundant, that whole mountains are composed of iron stone; whereas, other metals usually run in small veins. Besides the calciform ores of iron, which are either nearly pure, or else mixed with earths, as in spars, jasper, boles, basaltæ, &c. iron is mineralized with sulphur, as in the pyrites; or with both. An iron ore is likewise found, of a blue colour, and powdery appearance, which is thought to be of the same nature as Prussian blue. The coaly iron ores

* See Bergman's Essays; Magellan's improved edition of Cronstedt's Mineralogy; and the Phil. Trans. lxxviii. 37.

contain bitumen. The magnet, or loadstone, is an iron ore, whose constitution has not yet been accurately examined. Iron is also found in combination with the vitriolic acid, either dissolved in water, or in the form of vitriol.

To analyse the ores of iron in the humid way, they must be reduced to a very subtle powder, and repeatedly boiled in marine acid. If the sulphureous ores should prove slow of solution, a small quantity of nitrous acid must be added to accelerate the operation. The iron being thus extracted, the insoluble part of the matrix only will remain. Prussian alkali, being added to the decanted solution, will precipitate the iron in the form of Prussian blue. This precipitate, when washed and dried, will be equal in weight to six times the quantity of metallic iron it contains; and from this iron four parts in the hundred must be deducted, to allow for the iron which is contained in the Prussian alkali itself. But as this alkali, and every other preparation containing the Prussian acid, does not constantly afford the same quantity of iron, the most exact way, in the use of such preparations, consists in previously dissolving a known quantity of iron in vitriolic acid; and precipitating the whole by the addition of the Prussian alkali. This result will afford a rule for the use of the same alkali in other solutions. For as the weight of the precipitate obtained in the trial experiment, is to the quantity of iron which was dissolved and precipitated; so is the weight of the precipitate obtained from any other solution, to the quantity of iron sought.

If the iron be united to any considerable proportion of zinc or manganese, the Prussian blue must be calcined to redness, and treated with pale nitrous acid, which will take up the calx of zinc. The manganese may then be dissolved by nitrous acid, with the addition of sugar; and the remaining iron being dissolved by marine acid, and precipitated by mild mineral alkali, will afford 225 grains of precipitate for every 100 grains of metallic iron.

To examine the ores of iron in the dry way, the only requisite is fusion, in contact with charcoal. For this purpose eight parts of pulverized glass, one of calcined borax, and half a part of charcoal, are to be well mixed together. Two or three parts of this flux, being mixed with one of the pounded ore, and placed in a crucible, lined with a mixture of a little clay and pounded charcoal, with a cover luted on, is to be urged with the strong heat of a smith's forge for half an hour. The weight of the ore, in this experiment, should not exceed 60 grains. Other processes for determining the contents, or metallic product, of iron ores, are instituted by performing the same operations in the small, as are intended to be used in the large way.

In the large iron works, it is usual to roast, or calcine the ores of iron, previous to their fusion; as well for the purpose of expelling sulphureous or arsenical parts, as to render them more easily broken into fragments of a convenient size for melting. The mineral is melted, or run down, in large furnaces, from 16 to 30 feet high; and variously shaped, either conical or elliptical, according to the opinion of the iron master. Near the bottom of the furnace is an aperture for the insertion of the pipe of large bellows, worked by water or steam, or of other machines for producing a current of air; and there are also holes at proper parts of the edifice, to be occasionally opened, to permit the scoriæ and the metal to flow out, as the process may require. Charcoal, or coke, with lighted brushwood, is first thrown in; and when the whole inside of the furnace has acquired a strong ignition, the ore is thrown in by small quantities at a time, with more of the fuel, and commonly a portion of limestone, as a flux: the ore gradually subsides into the hottest part of the furnace, where it becomes fused; the earthy part

part being converted into a kind of glass; while the metallic part is reduced by the coal, and falls through the vitreous matter to the lowest place. The quantity of fuel, the additions, and the heat, must be regulated, in order to obtain iron of any desired quality; and this quality must likewise, in the first product, be necessarily different, according to the nature of the parts which compose the ore.

The iron which is obtained from the smelting furnaces is not pure; and may be distinguished into three states: white crude iron, which is brilliant in its fracture, and exhibits a crystallized texture, more brittle than the other kinds, not at all malleable, and so hard as perfectly to withstand the file: grey crude iron, which exhibits a granulated and dull texture when broken; this substance is not so hard and brittle as the former, and is used in the fabrication of artillery and other articles which require to be bored, turned, or repaired: and black cast iron, which is still rougher in its fracture; its parts adhere together less perfectly than those of the grey crude iron: this is usually fused again with the white crude iron.

Whenever crude iron, especially the grey sort, is fused again with contact of air, it emits sparkles, loses weight, and becomes less brittle. In order to convert it into malleable iron, it is placed on a hearth, in the midst of charcoal, urged by the wind of two pair of bellows. As soon as it becomes fused, a workman continually stirs it with a long iron instrument. During the course of several hours it becomes gradually less fusible, and assumes the consistence of paste. In this state it is carried to a large hammer, the repeated blows of which drive out all the parts that still partake of the nature of crude iron so much as to retain the fluid state. By repeated heating and hammering, more of the fusible iron is forced out; and the remainder, being malleable, is formed into a bar or other form for sale. Crude iron loses upwards of one-fourth of its weight in the process of refining.

Purified or bar iron is soft, ductile, flexible, malleable, and possesses all the qualities which have been enumerated under this article, as belonging exclusively to iron. When a bar of iron is broken, its texture appears fibrous; a property which depends upon the mechanical action of the hammer, while the metal is cold. Ignition destroys this fibrous texture, and renders the iron more uniform throughout; but hammering restores it.

If the purest malleable iron be bedded in pounded charcoal, in a covered crucible, and kept for a certain number of hours in a strong red heat (which time must be longer or shorter, according to the greater or less thickness of the bars of iron), it is found that by this operation, which is called cementation, the iron has gained a small addition of weight, amounting to about the hundred and fiftieth, or the two hundredth part; and is remarkably changed in its properties. It is much more brittle and fusible than before. Its surface is commonly blistered when it comes out of the crucible; and it requires to be forged, to bring its parts together into a firm and continuous state. This cemented iron is called steel. It may be welded like bar iron; but its most useful and advantageous property is that of becoming extremely hard when ignited and plunged into cold water. The hardness produced is greater in proportion as the steel is hotter, and the water colder. The colours which appear on the surface of steel slowly heated, are yellowish white, yellow, gold colour, purple, violet, deep blue, yellowish white; after which the ignition takes place. These signs direct the artist in tempering or reducing the hardness of steel to any determinate standard.

If

If steel be too hard, it will not be proper for tools which are intended to have a fine edge, because it will be so brittle that the edge will soon become notched; if it be too soft, it is evident that the edge will bend or turn. Some artists ignite their tools, and plunge them into cold water; after which, they brighten the surface of the steel upon a stone: the tool being then laid upon charcoal, or upon the surface of melted lead, or placed in the flame of a candle, gradually acquires the desired colour; at which instant they plunge it into water. If a hard temper be desired, the piece is dipped again, and stirred about in the cold water as soon as the yellow tinge appears. If the purple appear before the dipping, the temper will be fit for gravers, and tools used in working upon metals; if dipped while blue, it will be proper for springs, and for instruments used in the cutting of soft substances, such as cork, leather, and the like; but if the last pale colour be waited for, the hardness of the steel will scarcely exceed that of iron. When soft steel is heated to any one of these colours, and then plunged into water, it does not acquire nearly so great a degree of hardness, as if previously made quite hard, and then reduced by tempering. The degree of ignition required to harden steel is different in the different kinds. The best kinds require only a low red heat. The harder the steel, the more coarse and granulated its fracture will be; and as this is not completely remedied by the subsequent tempering, it is advisable to employ the least heat capable of affording the requisite hardness. It is a circumstance worthy of remark, that steel has a less specific gravity when hardened than when soft; but there are no circumstances, upon which a probable connection between these two properties, namely, the increased hardness and the diminished specific gravity, can be made out.

The usual time required for the cementation of steel, is from six to ten hours. If the cementation be continued too long, the steel becomes porous, brittle, of a darker fracture, more fusible, and incapable of being forged or welded. On the contrary, steel cemented with earthy infusible powders, is gradually reduced to the state of forged iron again. Simple ignition produces the same effect; but is attended with calcination of the surface. The texture of steel is rendered more uniform by fusing it before it is made into bars: this is called cast steel; and is rather more difficultly wrought than common steel, because it is more fusible, and is dispersed under the hammer if heated to a white heat.

When we consider the operations by which crude iron is brought into the malleable state, then converted into steel, and afterwards into a fusible metal, which is not malleable; we may perceive that steel-making is a kind of inversion of the process of refining iron, as practised in the first instance. When the calx of iron is mixed together in the smelting furnace, with combustible matter and glass, it will either be completely or partially revived, according to the management of the process. Much of the coal will however be so enveloped with the vitreous matter as to remain unburned: and the reduced iron, with which it may be in contact, will be in the same situation as forged iron in the cementing pot; that is to say, it will be in contact with coal at a very elevated temperature, and defended from the air. From the great infusibility of iron, it may reasonably be concluded that the reduced metal does not flow into the bottom of the furnace, until the charcoal has converted it into a fusible matter similar to steel, by the same action which takes place in cementation, whatever that action may be. Hence it must follow, that the various specimens of crude or cast iron will differ in their qualities, as well on account of the degree of cementation they have undergone, as the degree of reduction which has taken place among the metallic

parts,

parts, which are carried down, and form the whole mass. Since the coal, in the process of cementation, communicates or adds weight to the iron; and since crude iron, as well as steel, exhibits sparkles, and is more easily burned than other iron; it may therefore be concluded that, in the process of refining, that part of the inflammable substance which had united with the metal is burned, and leaves the iron much less fusible than before. Stirring the mass multiplies the contacts of the air with the burned substances; these surfaces of contact will therefore successively afford thin coats of infusible metal. In this manner it is found, that if a large piece of crude iron be exposed to heat in a wind furnace, the external part will be deprived of its fusibility during the time required to produce a strong heat in the whole mass; and the internal part will be melted, and run out, leaving the shell behind. Iron which is of the consistence of paste may therefore be considered, like any other paste, as a mixture of a fluid with a solid. It will be easily understood that the forging will bring the parts of difficult fusion together, and extrude the less refined and fluid parts: it will also be evident that this operation is not likely to drive out the whole of the fusible matter. When the iron has arrived at that state wherein the quantity of fibre or tough iron is sufficient to answer the mechanical purposes to which it is intended to be applied, the artist will consider it as sufficiently refined; and the residue of fusible iron contained in the bar answers, in all probability, the valuable purpose of connecting these infusible masses together. Thus we find that forged iron appears as if covered with a varnish, when urged to a white heat; we find that this varnish is more abundant in steel; and that iron and steel may be respectively welded together by application in this state; an effect which it would be very difficult to account for, in this most infusible of metals, if it were not for such an admixture. But cast steel, steel over-cemented, and crude iron, appear to be in the state of all other metals, platina excepted. They cannot be welded, because welding implies a partial fusion; or an effect similar to the glueing or uniting of solids by the application of a fluid, which afterwards becomes consistent. And if it be true that platina possesses this valuable property, it seems reasonable to infer that it must also consist of two metallic substances of different degrees of fusibility.

Crude iron, and steel of an uniform texture, consist therefore of a fusible combination of iron with the combustible substance of the coal, or something which is imparted from it; the crude iron differing from the steel simply in being over-cemented, and less pure, on account of the admixture of metallic calx, which can scarcely, perhaps, be avoided in the large process. It appears therefore that crude iron must pass through the state of steel before it can become forged iron; and consequently that the fabrication of steel from this last is a circuitous process, which can only be repaid by the absence of those unreduced parts which may exist in the crude iron. At some forges, however, where the ore, the flux, the fuel, and the management, are adapted to each other, the produce affords steel, when duly refined. At other manufactories, the crude iron is either refined, or converted into steel, by running it into thin plates, which are stratified with charcoal, and burned in a close furnace. In this way the metal is refined by degrees, without undergoing fusion; and if the heat be raised to that of cementation, the iron will not only be reduced, but converted into steel. In the forges of Carinthia the grey crude iron is also converted either into soft iron, or steel, according to the management of a somewhat similar process. The iron is fused in a large

large melting-pot; and a small quantity of water being thrown upon the surface of the metal, causes a thin plate to congeal, which is taken off; and, by continuing the operation, the greatest part of the fused iron becomes converted into plates. To produce steel, these plates are again fused, and kept a long time in an elevated heat; at the same time that the metal is defended from the contact of the air by a sufficient quantity of the vitreous slag. To produce soft iron, the plates are exposed to a continued roasting, while the air is constantly renewed by means of two pair of bellows. The extensive surface of the plates renders it unnecessary to use that agitation, or stirring, which is required when fused crude iron is refined. In these processes it is evident that the same matter in the crude iron, which it obtained in the smelting furnace, is employed, and supplies the place of the charcoal used in forming steel by cementation; and, on the other hand, that this substance, which prevented the crude iron from being soft, tough, and infusible, is burned away, together with a portion of the iron itself, while the remainder is left in a much purer state.

These are the facts observed at the furnaces. But the observations and inquiries of the chemist must be carried further, in order to determine what it is that iron gains or loses at the time of its conversion into its various states. It is found that crude iron approaches towards the soft state, not only by heating with exposure to the air, which burns the combustible addition, but likewise by fusion, without the free access of air. In this case, when the fusion has been complete, and the cooling gradual, it is found that a black substance is thrown up to its surface, which is more abundant the greyer or blacker the iron; and the same black substance is observed to coat the ladles of forged iron, which are used to take out the metal, and pour it into moulds for casting shot, and other articles. It appears therefore that the heated iron, like other heated fluids, is capable of holding a larger quantity of matter in solution than when cold; and that a portion of this black substance separates during the cooling, whether by the gradual effect of surrounding bodies, or by the contact of the ladle, in the same manner as various salts are separated, in part, from water, by a diminution of temperature. From chemical analysis, as well as from its obvious characters, this black substance is found to be plumbago, or the material used to make pencils, and commonly known by the name of black lead.

The presence of this black matter is likewise exhibited by dissolving steel, or crude iron, in acids, in which plumbago is insoluble, and therefore remains behind in the form of a powder. Hence likewise is deduced the cause of the black spot which remains upon steel, or crude iron, after its surface has been corroded by acids; for this spot consists of the plumbago which remains after the iron has disappeared by solution.

Solution in the vitriolic or marine acids, not only exhibits the plumbago contained in iron, but likewise possesses the advantage of shewing the state of its reduction by the quantity of inflammable air which is disengaged: for whether this aerial fluid be supplied by the phlogiston of the iron, or from the decomposed water, it is agreed on all hands that its quantity, in like circumstances, is proportional to that of the iron which is converted into calx. There are considerable differences between the various products of the smelting furnace in these respects; but it is found that the white crude iron affords the least quantity of inflammable air in proportion to its bulk, and leaves a moderate portion of plumbago; the grey crude iron affords more inflammable air, and more plumbago, than the
white;

white; and the softest bar iron affords most inflammable air of any, and little or no plumbago. The quantities of inflammable air*, at a medium, by ounce measures, were 62, afforded by 100 grains of the white crude iron; 71 by the grey crud. iron; and 77 by the malleable iron.

Hence it may be inferred that, in the white crude iron, the processes of reduction and cementation are both carried to a less extent than in the grey crude iron, which is produced by means of a stronger heat, excited with a larger quantity of fuel: and that the reduction of grey crude iron is still less perfect than that of the soft bar iron; though this last, by the refining in an open vessel, is so far from being more cemented, that it scarcely contains any plumbago at all.

It must be admitted; however, that the solution in acids serves only to support these general conclusions, in conjunction with the facts observed in the dry processes; but cannot accurately shew either the quantities of inflammable air or plumbago afforded by the several kinds of iron. For the plumbago, as it becomes disengaged, floats on the top of the vitriolic acid; where it gradually disappears, though insoluble in that acid. It must therefore be taken up by the inflammable air, and it is found that the volume of this air is diminished by the absorption. Hence there is a double source of inaccuracy from the loss of plumbago, and the contraction of the inflammable air.

On the whole then, since iron contains plumbago in a state of combination, of which it may be deprived by heat, with access of vital air, which converts it into the acid called fixed air, as Scheele's experiments shew (*see PLUMBAGO*); and since it recovers the plumbago by cementation with charcoal, there can be no question, but that this substance is originally afforded by the fuel. It appears also that the reduction of the metallic calx takes place first at a lower temperature; and that the combination of the base of fixed air follows at a greater heat. Whence, in the refining of iron, the plumbago is first burned, and the iron remains reduced; and in the cementation of bar iron, the metal is converted into steel, with blisters on its surface; which most probably arise from fixed air formed by the vital air of some portions of unreduced calx, uniting with the acidifiable base from the charcoal. And, lastly, as iron holds this acidifiable base, or phlogisticated acid, in solution, so likewise it may not be separable from this metallic solvent, without carrying a portion with it; in the same manner as salts, which crystallize in water, always take up part of the solvent in the formation of their crystals.

It would require many volumes to enumerate the leading uses of iron. This most valuable of metals is applied to so many, and such important uses, that we cannot look round us without seeing its effects. When we contemplate the innumerable effects of human industry, and ask ourselves the simple question, could this have been done without iron? there is not a single instance which will not immediately shew its value. It is indeed difficult to form an idea, how civilized society could exist without it.

ISINGLASS. This substance, though well known in the arts, has been greatly mistaken, not only with regard to the manner of its fabrication†, but as to the effects it produces. As Mr. Jackson has given a good account of isinglass, from his own observations and experiments, in the Philosophical Transactions for 1772, I shall here chiefly follow his authority.

* Acad. Par. 1786, pages 166, 167. The numbers in the text are given as a rough measure; for, in fact, there can be no medium.

† It is said to be made in the same manner as glue, by Pomet, Neumann, Lewis, and Chaptal.

The principal consumption of isinglass is in fining liquors of the fermented kind. It appears to do this merely by the mechanical effect of its organization, which forms a kind of strainer, or fine net work, and carries the gross impurities before it, as it subsides. Glue is unfit for this purpose, because it wants the peculiar structure. Isinglass itself, if converted into glue by boiling, though excellent for the purposes of cementing wood and other articles, is no longer useful for fining liquors.

Isinglass is made from certain fish found in the Danube, and the rivers of Muscovy. Willoughby and others inform us, that it is made of the found of the Beluga; and Neumann, that it is made of the *Huso Germanorum*, and other fish, which he has frequently seen sold in the public markets of Vienna. Mr. Jackson remarks that the sounds of cod, properly prepared, afford this substance, and that the lakes of America abound with fish from which the very finest sort may be obtained.

The sounds, or air bladders of fresh water fish, in general, are preferred for this purpose, as being the most transparent, flexible, delicate substances. These constitute the finest sorts of isinglass; those called book and ordinary staple, are made of the intestines, and probably the peritonæum of the fish. The Beluga yields the greatest quantity, as being the largest and most plentiful fish in the Muscovy rivers; but the sounds of all fresh-water fish yield, more or less, fine isinglass, particularly the smaller sorts, found in prodigious quantities in the Caspian sea, and several hundred miles beyond Astracan, in the Wolga, Yack, Don, and even as far as Siberia, where it is called *kle* or *kla* by the natives, which implies a glutinous matter; it is the basis of the Russian glue, which is preferred to all other kinds for its strength.

The sounds, which yield the finer isinglass, consist of parallel fibres, and are easily rent longitudinally; but the ordinary sorts are found composed of double membranes, whose fibres cross each other obliquely, resembling the coats of a bladder: hence the former are more readily pervaded and divided with subacid liquors; but the latter, through a peculiar kind of interwoven texture, are with great difficulty torn asunder, and long resist the power of the same menstruum; yet, when duly resolved, are found to act with equal energy in clarifying liquors.

Isinglass receives its different shapes in the following manner:

The parts of which it is composed, particularly the sounds, are taken from the fish while sweet and fresh, slit open, washed from their slimy *sordes*, divested of every thin membrane which envelops the sound, and then exposed to stiffen a little in the air. In this state, they are formed into rolls about the thickness of a finger, and in length according to the intended size of the staple: a thin membrane is generally selected for the centre of the roll, round which the rest are folded alternately, and about half an inch of each extremity of the roll is turned inwards. The due dimensions being thus obtained, the two ends of what is called short staple are pinned together with a small wooden peg; the middle of the roll is then pressed a little downwards, which gives it the resemblance of a heart, and thus it is laid on boards, or hung up in the air to dry. The sounds which compose the long staple, are larger than the former; but the operator lengthens this sort at pleasure, by interfolding the ends of one or more pieces of the sound with each other. The extremities are fastened with a peg, like the former; but the middle part of the roll is bent more considerably downwards; and in order to preserve the shape of the three obtuse angles thus formed, a piece of round stick, about a quarter of an inch diameter, is fastened in each angle

with

with small wooden pegs, in the same manner as the ends. In this state it is permitted to dry long enough to retain its form, when the pegs and sticks are taken out, and the drying completed : lastly, the pieces of isinglass are colligated in rows, by running packthread through the peg holes, for convenience of package and exportation.

The membranes of the book sort, being thick and refractory, will not admit a similar formation with the preceding : the pieces therefore, after their sides are folded inwardly, are bent in the centre, in such manner that the opposite sides resemble the cover of a book, from whence its name ; a peg being run across the middle, fastens the sides together, and thus it is dried like the former. This sort is interleaved, and the pegs run across the ends, the better to prevent its unfolding.

That called cake isinglass is formed of the bits and fragments of the staple sorts, put into a flat metalline pan, with a very little water, and heated just enough to make the parts cohere like a pancake, when it is dried ; but frequently it is overheated, and such pieces, as before observed, are useless in the business of fining. Experience has taught the consumers to reject them.

Isinglass is best made in the summer, as frost gives it a disagreeable colour, deprives it of weight, and impairs its gelatinous principles ; its fashionable forms are unnecessary, and frequently injurious to its native qualities. It is common to find oily putrid matter and *exuvie* of insects between the implicated membranes, which through the inattention of the cellar-man often contaminate wines and malt liquors in the act of clarification. These peculiar shapes might, probably, be introduced originally with a view to conceal and disguise the real substance of isinglass, and preserve the monopoly.

The sounds of cod and ling bear great analogy with those of the *accipenser genus* of Linnæus and Artedi, and are in general so well known, as to require no particular description. The Newfoundland and Iceland fishermen split the fish, as soon as taken, and throw the back bones, with the sounds annexed, in a heap ; but previous to incipient putrefaction, the sounds are cut out, washed from their slimes, and salted for use. In cutting out the sounds, the intercostal parts are left behind, which are much the best : the Iceland fishermen are so sensible of this, that they beat the bone upon a block with a thick stick, till the pockets, as they term them, come out easily, and thus preserve the sound entire. If the sounds have been cured with salt, that must be dissolved by steeping them in water, before they are prepared for isinglass ; the fresh sound must then be laid upon a block of wood, whose surface is a little elliptical, to the end of which a small hair brush is nailed, and with a saw knife the membranes on each side of the sound must be scraped off. The knife is rubbed upon the brush occasionally, to clear its teeth ; the pockets are cut open with scissors, and perfectly cleansed of the mucous matter with a coarse cloth : the sounds are afterwards washed a few minutes in lime water, in order to absorb their oily principle, and lastly in clear water. They are then laid upon nets to dry in the air ; but if intended to resemble foreign isinglass, the sounds of cod will only admit of that called book, but those of ling both shapes. The thicker the sounds are, the better the isinglass, colour excepted ; but that is of no consequence to the brewer, who is chief consumer.

This isinglass resolves into fining, like the other sorts, in sub-acid liquors, as stale beer, cyder, old hock, &c. and in equal quantities produces similar effects upon turbid liquors, except that it falls speedier and closer to the bottom of the

vessel, as may be demonstrated in tall cylindrical glasses; but foreign isinglass retains the consistency of fining preferably in warm weather, owing to the great tenacity of its native mucilage.

Vegetable acids appear to be in every respect best adapted to fining. It has long been a prevalent opinion, that sturgeon, on account of its cartilaginous nature, would yield great quantities of isinglass; but, on examination, no part of this fish, except the inner coat of the sound, promised the least success. This being full of rugæ, adheres so firmly to the external membrane, which is useless, that the labour of separating them supercedes the advantage. The intestines, however, which in the larger fish extend several yards in length, being cleansed from their mucus, and dried, were found surprisingly strong and elastic, resembling cords made with the intestines of other animals, commonly called cat-gut, and, from some trials, promised superior advantages, when applied to mechanic operations.

IVORY. The tusk or tooth of defence of the male elephant. It is an intermediate substance, between bone and horn, not capable of being softened by fire, nor altogether so hard and brittle as bone. Sometimes it grows to an enormous size, so as to weigh near two hundred pounds.

The entire tooth is of a yellowish, brownish, and sometimes a dark brown colour on the outside, internally white, hollow towards the root, and so far as was inserted into the jaw of a blackish brown colour. The finest, whitest, smoothest, and most compact ivory comes from the island of Ceylon. The grand consumption of this commodity is for making ornamental utensils, mathematical instruments, cases, boxes, balls, combs, dice, and an infinity of toys. There are many exquisite pieces of workmanship, as medals and chains, curious spinning-wheels, &c. made entirely out of one tooth. In his Prussian majesty's collection, there is a chair, a pair of chess tables, and sundry other curiosities of ivory. The workmen have methods also of tingeing it of a variety of colours.

From four drams of rasped ivory treated with rectified spirit, Neumann obtained three grains of extract, in taste somewhat rancid, but of no smell: the remainder inclined a little to reddish. On boiling four drams in pure distilled water, and inspissating the decoction, he obtained six drams of jelly, or a gelatinous extract; but as the dried residuum weighed three drams and a scruple, it is plain that in the six drams of jelly there were only two scruples afforded by the ivory, all the rest being water; and hence we learn what a large proportion of water is retained in jellies. The jelly tasted manifestly saline; the remaining ivory proved considerably brittle and earthy.

Diluted vitriolic acid totally dissolves ivory, and affords a precipitate of selenite. Phosphoric acid is disengaged. The nitrous and marine acids likewise decompose ivory. Pure alkalis combine with its oily part, and destroy its texture. The products of destructive distillation are nearly the same as obtained from other animal substances, viz. water impregnated with volatile alkali, some concrete alkali, oil, and a residual coal, which by incineration becomes white, and consists of phosphorated lime. The coal of ivory is used in the arts under the denomination of ivory black. Particular vessels are used in the manufactory of this pigment, for the purpose of rendering it perfectly black.

Some travellers speak of the tooth of the sea-horse as an excellent ivory; but it is too hard to be sawed or wrought like ivory. It is used for making artificial teeth.

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JACINTA LA BELLA. The jacinta la bella of the Italians is a garnet of a yellowish hue : but when it is more of a reddish colour, it is then called vermeille by the French.

JACK, BLACK. The miners' term for blende, or mock lead. See **BLENDE**.

JADE. *Lapis nephriticus, jaspacates.*

The true lapis nephriticus seems to belong to the siliceous order ; as it gives fire with steel, and is semi-pellucid like flint ; it does not harden in fire, but melts by the solar heat in the focus of a burning lens, into a transparent green glass with some bubbles. That called by the name of *circumcision stone*, which comes from the Amazon river, melts easier, in the same solar fire, into a brown opaque glass, which is far less hard than the stone itself.

This stone is superior in hardness to quartz, though, from its unctuousity to the touch, one would suspect it to contain a large portion of argillaceous earth, or rather of magnesian earth, as Mr. Kirwan seems to suspect.

Its specific gravity is from 2.970 to 3.389. It is of a granular texture, of a greasy look, and exceedingly hard ; is scarcely soluble in acids, at least without particular management, and is infusible in the fire. M. Saussure seems to have extracted iron from it.

It is sometimes of a whitish milky colour, from China ; but mostly of a greenish, or deep green colour, from America, or of a grey, yellowish and olive colour. The jade is vulgarly denominated lapis nephriticus, from being supposed to cure nephritic pains by external application to the loins.

The semi-transparency, hardness, and specific gravity are the characters by which the lapis nephriticus may be distinguished from other stones.

JALAP is the root of a species of convolvulus, with leaves like those of ivy, but not so thick, and beautiful red flowers, which have this remarkable property, that they open in the night, and shut again on the least appearance of the sun ; whence the plant is called by the French *Belle de nuit*, the beauty or fair one of the night : in rainy or cloudy days the flowers open a little, but fall off the sooner, as if day-light was injurious to them. The jalap plant is a native of the province Chalapa or Xalapa, in New Spain, from whence its name is derived, and written, according to the pronunciation of different languages, *Jalapa* or *Jalapium*, *Gialappa*, *Chalapa*, *Xalapa*, *Zalapa*, &c. The roots raised in Europe have been found much weaker than the American.

Jalap is brought over in thin slices ; of which the best are compact and hard, so as not to be broken by the fingers ; ponderous, of a dark brown colour, of a glossy resinous appearance, or at least furnished with resinous streaks and circles ; easily inflammable, of no smell, or a faint unpleasant one, and of a slight acrid taste : the fine dust which flies off in powdering them, provokes sneezing. Those which are thoroughly resinous, are not liable to be worm-eaten, the worms preying chiefly upon the gummy or mucilaginous parts, and not touching the resin, or at least not till these are consumed : hence we may suppose the worm-eaten roots to have been originally of a bad kind, produced in moist soils or rainy seasons, &c. and hence the worm-eaten may be employed for making extracts equally with any other, the resin being equal in goodness, though less in quantity.

From sixteen ounces of good jalap-root, Neumann obtained, by spirit of wine, five ounces and four scruples of resinous extract, and afterwards by water, two ounces and a half of a gummy one: on applying water at first, he gained four ounces and a half of gummy extract, together with six drams of a resinous matter, which fell to the bottom in evaporating the decoction; the remainder yielded, with spirit, three ounces of resin: the indissoluble part amounted in the first case to eight ounces three drams, in the latter to seven ounces six drams: By precipitating a spirituous tincture of the root with water, he gained, from a pound, four ounces of pure resin.

The inferior sorts of jalap yield less resinous and more gummy extract; such must have been that employed by Boulduc, who obtained, from sixteen ounces, only two ounces five drams and a scruple of resinous extract; but upwards of eight ounces and a half of a gummy one.

It has been remarked, that jalap possesses a notable degree of fermentative power; exciting this action in gross, sweet, vegetable juices, such as melasses, and at the same time impregnating them with its purgative quality. I am informed however, that this is by no means the case, but that it is used to check the rapid progress of fermentation in the manufacture of melasses' spirits, for which purpose it is strewed over the surface of the liquor. It is a late discovery, that common resin will do as well. This effect requires explanation. Perhaps the resin may combine with part of the ardent spirit, at the instant of its extrication. If this be true, it seems likely that so much of the spirit may be prevented from rising in distillation, and more loss may be sustained by this practice than might have followed from the activity of the fermentation.

JAPAN EARTH. *Catechu*, so called from its having been long supposed by the Europeans to be an earthy substance found in Japan, is neither one nor the other. It belongs to the class of gummy-resins; being such a combination of gummy and resinous matter, as the extracts made from vegetables by water. In effect, it is no other than a preparation of this kind, obtained by inspissating a watery decoction, or the expressed juice of the fruit of a certain palm-tree, growing plentifully on the sea-coasts in Coromandel, Cambia, Racaim, Manora, Daman, and several other parts of the East Indies. The fruit, held there as a delicacy, is called *fause*, its kernel *creca*, and the leaves of the tree *betel*; hence the names of the plant, *Palma fauselifela*, *arecifera*, &c.

The best Japan earth is that prepared by expression, but the greater part of what is brought to us is a true watery extract. There are considerable differences in the product, according to the manner in which the process has been managed, and the degree of maturity or perfection of the fruit itself; that lime-water, gum-arabic, liquorice, vitriol, or other like substances are added, is a groundless conjecture. Some sorts are of a pale reddish-brown colour, others of a dark blackish brown, or quite black like bitumen; some are ponderous, and others light; some compact, and others porous; some more and others less astringent. The best sort is of a dark reddish-brown, dry, heavy, hard, compact and glossy; chewed, it discovers at first a bitterish styptic taste, which is followed by an agreeable sweetness.

Japan earth, when pure, is almost totally dissolved; its astringency at least is totally extracted both by water and spirit. Four ounces of the best Neumann could procure, yielded with water three ounces and six drams of solid extract; after which, rectified spirit took up no more than twelve grains; the indissoluble part consisted chiefly of sand, woody and other foreign matters. Four ounces

of the same Japan earth, treated first with rectified spirit, gave just three ounces of resinous extract; the residuum still yielded with water five drams two scruples and eight drams of a gummy one. Another parcel yielded, on the same quantity, two drams more of spirituous than of watery extract; but all the sorts agree in the material points, namely, 1. That the spirituous tincture is of a redder colour, brighter, clearer, and more fluid than the watery; the latter appearing brownish, quite thick, and at last curdly. 2. That the spirituous extract inspissated, proves stronger, more astringent, and more disagreeable than the watery; the latter possessing the agreeable sweetness of the Japan earth itself, unimproved rather than injured. 3. That the extracts made by water after spirit, and by spirit after water, have no remarkable taste.

Hence, when a strong astringent is required, whether for external or internal purposes, we are directed to the spirituous tincture and extract; and for a milder and more grateful corroborant, to the watery extract. A little of this last taken into the mouth at bed-time, and suffered slowly to dissolve, is said to be remarkably serviceable in disorders of the throat.

JARGON. A hard gem brought from the East Indies in the form of thin plates, which appear to be split from pebbles. They are of different colours, white, black, yellow, and brown, about as hard as the sapphire. As they have a great resemblance to the diamond, they are substituted instead of it in jeweller's work, sometimes fraudulently. It is probable that the great specific gravity of this stone, which in some specimens exceeds that of the ponderous spar, may be attended with an extraordinary degree of refractive power, on which the brilliancy of precious stones depends. See **DIAMOND**.

Romare says, that the jargon is found in Brasil, but Romé de l'Isle informs us that it comes from Ceylon, and that its form consists of two tetrahedral pyramids of equal sides, separated by a short prism. M. D'Arcet exposed it to a violent heat in a porcelain test. Its surface was a little vitrified, and it stuck to the vessel; whence it appears that the jargon has not the least affinity to the diamond, which is destructible by fire.

M. Klaproth analysed the jargon of Ceylon, and found that more than two thirds of its weight consisted of an earth soluble in acids, but different in its properties from any other of the earths. See **EARTH OF THE JARGON**.

JASPACHATES. See **JADE**.

JASPER. *Jaspis.* (The Diaspro of the Italians.)

All opaque flints are called by this name, whose texture resembles dry clay, and which have no other known quality, whereby they may be distinguished from other flints, except that they may be more easily melted in the fire; and this quality, perhaps, may proceed from the mixture of iron. It often breaks with conchoidal surfaces; is capable of a fine polish; its colour is generally reddish or green, or striped; but it is also found blue, grey, or whitish; its specific gravity is from 2.68 to 2.778 or more, when it contains more iron.

Jasper is infusible alone with the blow pipe; with the mineral alkali it is only partially soluble, separating itself with effervescence, into small particles; but it melts with *borax* or *microcosmic salt*, without any effervescence.

According to Bergman, in his *Sciagraphia*, it is composed of *siliceous earth*, united to an argill very full of iron. The mineral acids have no action upon jasper in a short time, but at the end of some months it is found corroded, if immersed in them. A small piece of green jasper having been treated with the vitriolic.

vitriolic acid, gave some crystals of alum, and some martial vitriol, which demonstrates that argill and iron enter into its composition.

M. Daubenton mentions 15 varieties of jasper. 1. The *green*, from Bohemia, Silesia, Siberia, and the shores of the Caspian sea. This seems to be the *pavonium* of Aldrovandus. 2. The *red*, or the *diastro rosso* of the Italians, which is not so common, nor in such great masses, as the green. 3. The *yellow*, from Freyberg and Rochtliz; it is sometimes of a citron colour, and looks as if composed of silky filaments. This is called the *silk jasper*. 4. *Brown*, from Dalecarlia, in Finland and Sweden. 5. The *violet*, from Siberia. 6. The *black*, from Sweden, Saxony, and Finland. This is the *paragone antico* of the Italians. 7. The *blueish grey*, which is very rare. 8. The *milky white*, of which Pliny speaks; it is found in Dalecarlia. 9. The *variegated* with *green*, *red*, and *yellow* clouds. 10. The *blood stone*, which is green with red specks, from Egypt, and was supposed to stop the blood. 11. The *veined*, with various colours. When these veins have the resemblance of letters, it is then called *jaspe grammatique* by the French. Some of this kind are found near Rochelle, in France, and called *polygrammatiques* by the curious in these trifling accidental qualities. 12. That which has various coloured zones. 13. That called *florito* by the Italians, which has its various colours promiscuously, without any order. 14. When the jasper has a great number of colours together, it is then (very improperly) called universal. 15. Lastly, when the jasper is found to contain some portions of agate, it is then called *agateized jasper*.

JELLY. An animal substance soluble in water whether hot or cold. Its principal properties are detailed under the article **JELLY**. It is used either as food, or as a cement in the arts under the name of glue. Messrs. Parmentier and Pellerier made some judicious experiments upon glue made from bones by M. Grenet, of which an account is inserted in the 13th volume of the *Annales de Chimie*, p. 192. Six pounds of raspings of bone from the button-mould makers were put into a copper boiler with twenty-four pints of water, and in that state left to soak for two days without heat. At this period the vessel was placed on a fire, and after the expiration of one hour the fluid was in a state of ebullition, which was continued for nine hours. The materials were then left to subside for a night. The supernatant fluid, or glue, was by this means rendered clear. It was drawn off with a syphon. The quantity was fourteen pints, and two pints more were obtained by pressure from the dregs. This clear fluid was afterwards concentrated by farther evaporation, then suffered to cool for half an hour, and poured into wooden moulds. In the course of the day it had acquired the consistence of a firm jelly, which was cut into cakes, and dried upon a net. Fourteen days were requisite for this purpose, in the shade, the weather being rainy and damp. The quantity of glue was fifteen ounces and four drams, with the addition of four drams more obtained by pressure from the dregs. The dried residue weighed four pounds three ounces, and the loss was thirteen ounces. The glue was therefore one sixth of the weight of the bones.

Ivory raspings treated in the same manner, afforded upwards of one fifth part of their weight of glue.

The dark colour of glue was found to arise from the action of the heat in the last evaporation. These intelligent chemists, adverting to the fact, that singlafs is rendered clear and white by fumigation with sulphur; but at the same time reflecting, that glue not being composed of thin fibres, was incapable of undergoing

going this process, as to its interior part, determined to try the solution of sulphureous or volatile vitriolic acid. They prepared a pale jelly by a short ebullition of raspings of bones in the smallest possible quantity of water. To this they added a little water charged with sulphureous acid, and mixed the fluids well together. The experiment succeeded. They proposed as a preliminary operation to bleach the raspings by the same means, where a pale-coloured glue is required.

These commissaries found, that the glue manufactured by M. Grenet was equal in quality to the best made in England, or elsewhere. They could not make glue from horn.

JESUITS BARK. See PERUVIAN BARK.

JET. *Gages, Succinum nigrum*. Lat. *Jet*, or *Jayet*. French.

The *jet*, the *lapis obsidianus*, and the *fossil wood*, penetrated by mineral inflammable matter, are often confounded together, on account of their black glossy colour. But the *lapis obsidianus* is a volcanic glass, and jet is a compact bitumen. Jet is much harder than asphaltum, always black, susceptible of a good polish, and glossy in its fracture, which is conchoidal; its specific gravity is 1.744; it melts in a moderately strong heat, with a disagreeable smell; when burnt, it leaves a grey earthy ochrous residuum; it is insoluble in spirit of wine.

It is found in *England, Scotland, France, Italy, Germany, &c.* Wallerius, Bomare, and others assert, that it floats on water; a circumstance which, if true, must indicate a specific gravity not greatly exceeding the half of the above, which is from Kirwan.

The use of this fossil consists in the manufacture of small toys. It is also said to be an ingredient in varnishes.

JEWS PITCH. See ASPHALTUM.

JUICES OF PLANTS. The juices of several plants are expressed to obtain their essential salts, and for several medicinal purposes, with intention either to be used without further preparation, or to be made into syrups and extracts.

The general method of extracting these juices is, by pounding the plant in a marble mortar, and then by putting it into a press. Thus is obtained a muddy and green liquor, which generally requires to be clarified, as we shall soon observe.

The juices of all plants are not extracted with equal ease. Some plants, even when fresh, contain so little juice, that water must be added while they are pounded, otherwise scarcely any juice would be obtained by expression. Other plants, which contain a considerable quantity of juice, furnish by expression but a small quantity of it, because they contain also much mucilage; which renders the juice so viscid that it cannot flow. Water must also be added to these plants to obtain their juice.

The juices thus obtained from vegetables by a mechanical method, are not, properly speaking, one of their principles, but rather a collection of all the proximate principles of plants which are soluble in water; such as the saponaceous extractive matter, the mucilage, the odoriferous principle, all the saline and saccharine substances; all which are dissolved in the water of the vegetation of the plants. Besides all these matters, the juice contains some part of the resinous substance, and the green colouring matter. These two latter substances, not being soluble in water, are only interposed between the parts of the other principles which are dissolved in the juice, and consequently disturb its transparency.

They nevertheless adhere together in a certain degree, and so strongly in most juices, that they cannot be separated by filtration alone.

When therefore these juices are to be clarified, some previous preparations must be used by which the filtration may be facilitated. Juices which are acid, and not very mucilaginous, are spontaneously clarified by rest and gentle heat. The juices of most anti scorbutic plants abounding in saline volatile principles, may be disposed to filtration merely by immersion in boiling water; and as they may be contained in closed bottles while they are thus heated in a water bath, their saline volatile part, in which their medicinal qualities chiefly consist, may thus be preserved. Fermentation is also an effectual method of clarifying juices which are susceptible of it; for all liquors which have fermented, clarify spontaneously after fermentation. But this method is not used to clarify juices, because many of them are susceptible of only an imperfect fermentation, and because the qualities of most of them are hindered by that process.

The method of clarification most generally used, and indispensably necessary for those juices which contain much mucilage, is by boiling with the white of an egg. This matter, which has the property of coagulating in boiling water, and of uniting with mucilage, does accordingly, when added to the juice of plants, unite with and coagulate their mucilage, and separates it from the juice in form of scum, together with the greatest part of the resinous and earthy matters which disturb its transparency. And as any of these resinous matters which may remain in the liquor, after this boiling with the white of eggs, are no longer retained by the mucilage, they may easily be separated by filtration. See FILTRATION.

The juices, especially before they are clarified, contain almost all the same principles as the plant itself, because, in the operation by which they are extracted, no decomposition happens, but every thing remains, as to its nature, in the same state as in the plant. The principles contained in the juice are only separated from the grosser, oily, earthy, and resinous parts, which compose the solid matter that remains under the press. These juices, when well prepared, have therefore exactly the same medicinal qualities as the plants from which they are obtained. They must evidently differ from each other, as to the nature and proportions of the principles with which they are impregnated, as much as the plants from which they are extracted differ from each other in those respects.

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KALI is a maritime plant, from the ashes of which a considerable quantity of mineral fixed alkali is obtained by lixiviation. See ALKALI (FIXED MINERAL). Henckel informs us, that by boiling the plant in water, and by evaporating the decoction, he obtained a considerable quantity of sea salt.

KANEL COAL. See CANNEL COAL.

KAOLIN. The Chinese name of an earth used as one of the two ingredients of the oriental porcelain. Some of this earth was brought from China, and examined by M. Reaumur. He found that it was infusible, and supposed it to be a talcy earth; but Macquer supposes it to contain clay, because it forms a tenacious paste with the other ingredient called petuntze, which has no tenacity. Bomare found, that it was a compound of clay, or calcareous earth, mica, and small quartz crystals. He says that he has found a similar earth upon a stratum of granite, and conjectures that it may be a decomposed granite.

As porcelain is now manufactured in various parts of Europe, some mineralogists have applied the term kaolin to the porcelain clay.

KARABE, or CARABE. See AMBER.

KARAT. The fineness of gold is commonly noted by karats. Pure gold being considered to be divided into twenty-four equal parts, or karats; it is then said to be twenty-four karats fine. If the quantity of pure gold in any mass be less than this, that quantity only is noted in expressing the fineness. Thus, for example, if two parts out of the twenty-four be copper or other base metal, the gold is said to be twenty-two karats fine. This is the standard of British coin. See ASSAY.

The karat is a real weight used by jewellers, divided by us into four grains: but these grains are less than the grains of troy-weight; four grains troy being equal to five of these sub-divisions of the karat, according to David Jefferys. See DIAMOND.

KEDRIA TERRESTRIS. Barbadoes tar; a mineral oil resembling soft pitch. It is viscid, and of a brown black, or reddish black colour, easily fusible, and burning with much smoke and foot. Ardent spirit does not dissolve it, but mineral alkali extracts a portion of the acid of amber.

KEFEKIL. A stone of a white or yellow colour, soapy feel, and moderate hardness which increases in the fire. It is the substance of which the large Turkey pipes are made. It is found in Crim Tartary, in Canada, in Flanders, and elsewhere. The Tartars use it instead of soap, as do likewise the country people in the barony of Hierges, in Austrian Flanders. Wiegleb found it to consist of equal parts of magnesia and silice, whence it seems to operate as a fullers-earth. See EARTH (FULLERS).

KERMES (*coccus ilicis*, Lin.) is an insect found in many parts of Asia, and the south of Europe. It was known to the ancients by the name of *coccum scarlatinum*, *coccus baptricus*, *coccus insectarius*, *granum tinctorium*. That which came from Galatia and Armenia was preferred; but at present it is gathered chiefly in Languedoc, Spain, and Portugal.

The kermes lives on a small kind of oak (*quercus coccifera*, Lin.). The females grow big, and at length remain motionless; when they are nearly the size and shape of a pea, and of a reddish brown colour. On account of their figure, they were a long time taken for the seeds of the tree on which they live; whence they were called *grains of kermes*. They also bore the name of vermilion.

The first who has spoken of them with any accuracy is Peter de Quiqueran, bishop of Senes, who mentions them in his book; *De Laudibus Provinciae*, 1550.

The history of this insect may be seen in a memoir of Nissolle, *Acad. des Sciences*, 1714, and more particularly in Reaumur's *Mémoires pour servir à l'Histoire des Insectes*, tom. iv.

Kermes has been supposed to have derived its name from an Arabic word, signifying a little worm, *vermiculus*; whence the name of vermilion, which has also been given it. Astruc derives the name from two Celtic words, one of which signifies *an oak*, the other *an acorn**.

The kermes fixes itself to the back of the shrub on which it is found, by means of a cottony down which it is capable of furnishing. Mr. Chaptal has observed, that this down, like that of all the insects of this kind, has many characteristics of the caoutchouc; it is insoluble in alcohol, melts at the heat of boiling water, and burns with a flame on the coals. That learned chemist gave Bartholote the following description of the mode of gathering it in Languedoc:

About the middle of May they begin to gather kermes, which is then arrived at its ordinary size, and in colour and shape resembles a small sloe (prunelle). This harvest generally continues to the middle of June, and sometimes longer, if the great heats be retarded, or no violent rains fall; for one heavy storm of rain is sufficient to put an end to the gathering for that year.

In this occupation women are generally employed. They set out early in the morning, with a lantern, and a glazed earthen pot, to pick off the kermes from the branches with their fingers before day. This time is the most favourable: 1st. Because the leaves, which are prickly, are then less troublesome, being softened by the morning dew. 2dly. Because the kermes weighs more; whether because it is not dried by the sun, or because it has parted with fewer of its young, which are hatched by the warmth. Some, however, are bold enough to gather it in the day-time, but this is rarely done.

A single person may gather one or two pounds a-day.

At the beginning of the harvest, the kermes weighs more, but fetches a less price than at the end, when it is drier and lighter.

The price of fresh kermes varies also according to the demand for it, and its scarcity. It commonly sells for fifteen or twenty sous a pound, at the beginning of the gathering, and for thirty or forty towards the end.

The buyers are obliged as soon as possible to stop the progress of the eggs, in order to prevent the young contained in the shell from getting out. This shell is nothing but the body of the mother, distended by the growth of the eggs. The female has no wings: it settles itself on a leaf, where it fixes: the male comes to fecundate it: and it afterwards increases in size merely from the growth of the eggs. To kill the young contained in these, the kermes is steeped ten or twelve hours in vinegar, which requires less time, as half an hour is sufficient. It is afterwards dried on linen cloths. This operation gives it a colour like that of red wine.

If the living insect be bruised, it gives out a red colour. Its smell is somewhat pleasant; its taste a little bitter, rough, and pungent. When dry it imparts this smell and taste to water, and also to alcohol, to both which it gives a deep red colour. This colour is retained by the extracts made from these infusions.

To dye spun worsted with kermes, it is first boiled half an hour in water with bran; then two hours, in a fresh bath, with one-fifth of Roman alum, and one-tenth of tartar, to which *four water* is commonly added; after which it is taken out, tied up in a linen bag, and carried to a cool place, where it is

* Mémoire pour servir à l'Histoire Naturelle de Languedoc.

left some days. To obtain a full colour, as much kermes as equals three-fourths, or even the whole of the weight of the wool, is put into a warm bath, and the wool is put in at the first boiling. As cloth is more dense than wool, either spun or in the fleece, it requires one fourth less of the salts in the boiling, and of kermes in the bath. Less proportions of kermes will produce lighter and paler colours. If we want a succession of shades, we must, as usual, begin with the deepest.

Hellot directs a small handful of cot or refuse wool to be thrown into the boiler in which the kermes is, and to let it boil a moment before the wool to be dyed is put in. This will absorb a kind of black dregs, and the wool afterwards dipped will take a better colour. Before the wool that is just dyed is taken to the river, it may be dipped in a bath of water a little warm, in which a small quantity of soap has been dissolved. In this way the colour will acquire more brightness, though it will be rendered a little rosy, that is, will have a crimson cast.

By using kermes and tartar, without alum, and with as much solution of tin as is required for a scarlet with cochineal, Hellot obtained a very lively cinnamon colour in a single bath. Cloth steeped in a solution of sulphat of potash, took with kermes a pretty fine and permanent agate gray: in a solution of sulphat of iron and tartar, a fine gray: in a solution of tartar and sulphat of copper, an orange colour: and the same with nitrat of copper. Solution of bismuth a deep drop by drop to a kermes bath, produced a violet. All acids convert it to a cinnamon colour, which inclines more or less to red, according as the acids are weak, and their quantity small. Alkalis render its colour dull and rosy.

The colour that kermes imparts to wool, has much less bloom than the scarlet made with cochineal; whence the latter has generally been preferred, since the art of heightening its colour by means of solution of tin has been known. Berthollet.

KERMES MINERAL. See ANTIMONY.

KILLAS. This stone is chiefly found in Cornwall; its colour is pale gray or greenish gray; its texture either lamellar or coarsely granular: the lamellar is softer and less martial than the roof shistus: its specific gravity from 2.63 to 2.666.

Kirwan found an hundred grains of the lamellar sort to contain about 60 of silix, 25 of argill, 9 of magnesia, and 6 of iron. The greenish sort contains more iron, and gives a greenish colour to the nitrous acid.

KINGDOMS. Naturalists and chemists divide all natural bodies into three great classes, called kingdoms, namely, the mineral, the vegetable, and the animal kingdoms. The utility of these divisions appears to be in a great measure confined to the natural history of the various subjects examined by the chemist. The distinctive criterions of their respective principles are difficult, and perhaps impossible to be ascertained, excepting in bodies of no great simplicity; for none of the principles of organized bodies exhibit their peculiar characters when resolved by putrefaction or otherwise into their simplest parts. See ANIMAL KINGDOM, VEGETABLE KINGDOM, MINERAL KINGDOM.

KOLMORD MARBLE. A white calcareous stone of a scaly texture, interspersed with spots of steatites, or soap rock, either green or black.

KUPFER NICKEL. See NICKEL.

LABDANUM.

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LABDANUM. A resin of a species of cistus in Candia, of a blackish colour. The country people collect it by means of a staff, at the end of which are fastened many leather thongs, which they gently strike on the trees. They form it into cylindrical pieces, which are called labdanum in tortis. It is greatly adulterated by the addition of black sand, and is used as an astringent.

LABORATORY. A place properly fitted up for the performance of chemical operations. The several laboratories intended for the preparation of articles of the materia medica, or the arts, in the large way, have their respective accommodations and contrivances, the description of which would occupy several volumes. The philosophical chemist, whose operations afford products chiefly of value for the results they exhibit, naturally endeavours, as well for the advantage of time, as expence, to perform all his operations on as small a scale as possible. It was once thought to be indispensably necessary that a philosophical chemist should be provided with a regular laboratory, or room fitted up with furnaces and other apparatus, on a considerably extensive scale. This is no doubt of great utility and advantage; but the researches of Bergman, Morveau, and other eminent chemists, have shewn, that much, if not most of the chemical operations may be performed with the blow-pipe, or by very small glass vessels, and a spirit lamp, with greater speed, perspicuity, facility, and cheapness, than where larger quantities of the materials are used. But as the proportional quantities of products, and the indications afforded by experiment for conducting manufacturing processes, are more accurately deduced from considerable quantities, I shall in this article give the excellent sketch of a laboratory, as I find it in Macquer's Dictionary.

As chemistry is a science founded entirely on experiment, we cannot hope to understand it well, without making such experiments as verify most of the known fundamental operations, and also such as reasoning, analogy, and the spirit of inquiry, never fail to suggest to those whose taste and suitable talents lead them to this essential part of experimental philosophy. Besides, when a person himself observes, and operates, he must perceive, even in the most common operations, a great variety of small facts, which must necessarily be known, but which are not mentioned either in books or in memoirs, because they are too numerous, and would appear too minute. Lastly, how many qualities are in the several agents, of which no just notion can be given by writing, and which are perfectly well known as soon as they have been once made to strike our senses.

A chemical laboratory necessarily occasions certain expences, but not so much as is generally believed, when the operator knows how to manage his utensils, and to employ only the proper quantity of the several substances upon which he operates; and lastly, when he chooses the least expensive methods of attaining his purposes.

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Many people think, that a laboratory level with the ground is most convenient, for the sake of water, pounding, washing, &c. It certainly has these advantages; but it is also subject to very great inconvenience from moisture.

Constant moisture, though not very considerable and sensible in many respects, is a very great inconvenience in a chemical laboratory. In such a place, moist saline matters become moist in time, and the inscriptions fall off, or are effaced; the bellows rot; the metals rust; the furnaces moulder, and every thing almost spoils. A laboratory therefore is more advantageously placed above than below the ground, that it may be as dry as possible. The air must have free access to it; and it must even be so constructed, that, by means of two or more opposite openings, a current of air may be admitted to carry off any noxious vapours or dust.

In the laboratory a chimney ought to be constructed, so high that a person may easily stand under it, and as extensive as is possible; that is, from one wall to another. The tube of this chimney ought to be as high as is possible, and sufficiently contracted to make a good draught. As charcoal only is burnt under this chimney, no soot is collected in it; and therefore it need not be so wide as to allow a chimney-sweeper to pass up into it.

Under this chimney may be constructed some brick furnaces, particularly a melting furnace, a furnace for distilling with an alembic, and one or two ovens like those in kitchens. The rest of the space ought to be filled up with stands of different heights, from a foot to a foot and a half, on which portable furnaces of all kinds are to be placed. These furnaces are the most convenient, from the facility of disposing them at pleasure; and they are the only furnaces which are necessary in a small laboratory. A double bellows of moderate size must also be placed as commodiously under the chimney, or as near as the place will allow. These bellows are sometimes mounted in a portable frame; which is sufficiently convenient when the bellows is not more than eighteen or twenty inches. These bellows ought to have a pipe directed towards the hearth where the forge is to be placed.

The necessary furnaces are, the simple furnace, for distilling with a copper alembic; a lamp furnace; two reverberatory furnaces, of different sizes, for distilling with retorts; an air or melting furnace, an essay furnace, and a forge furnace.

Under the chimney, at a convenient height, must be a row of hooks driven into the back and side walls; upon which are to be hung small shovels; iron pans; tongs; straight, crooked, and circular pincers; poker; iron rods, and other utensils for disposing the fuel and managing the crucibles.

To the walls of the laboratory ought to be fastened shelves of different breadths and heights; or these shelves may be suspended by hooks. The shelves are to contain glass vessels, and the products of operations, and ought to be in as great a number as is possible. In a laboratory where many experiments are made, one cannot have too many shelves.

The most convenient place for a stone or leaden fountain to contain water is a corner of the laboratory, and under it a cistern ought to be placed with a pipe, by which the water poured into it may discharge itself. As the vessels are always cleaned under this fountain, cloths and bottle brushes ought to be hung upon hooks fastened in the walls near it.

In the middle of the laboratory a large table is to be placed, on which mixtures are to be made, preparations for operations, solutions, precipitations, small

small filtrations; in a word, whatever does not require fire, excepting that of a lamp.

In convenient parts of the laboratory are to be placed blocks of wood upon mats; one of which is to support a middle-sized iron mortar; another to support a middle-sized marble, or rather hard stone mortar; a third to support an anvil. Near the mortars are to be hung scarves of different sizes and fineness; and near the anvil are hung a hammer, files, rasps, small pincers, scissars, sheers, and other small utensils necessary to give metals a form proper for the several operations.

Two moveable trestles ought to be in a laboratory, which may serve to support a large filter mounted upon a frame, when it is required. This apparatus is removed occasionally to the most convenient place.

Charcoal is an important article in a laboratory, and it therefore must be placed within reach; but as the black dust which flies about it whenever it is stirred is apt to soil every thing in the laboratory, it had better be in some place near the laboratory, together with some furze, which is very convenient for kindling fires quickly. This place serves, at the same time, for containing bulky things which are not often wanted; such as furnaces, bricks, tiles, clay, fire-clay, quick-lime, sand, and many other things necessary for chemical operations.

Lastly, a middle-sized table, with solid feet, ought to be enumerated amongst the large moveables of a laboratory, the use of which is to support a porphyry, or levigating stone, or rather a very hard and dense grit-stone, together with a grinder made of the same kind of stone.

The other small moveables or utensils of a laboratory are, small hand-mortars of marble, iron and glass, and their pestles; earthen, stone, metal, and glass vessels.

Some white writing paper, and some paper not glued for filtrations; a large number of clean straws, eight or ten inches long, for stirring mixtures in glasses, and for supporting paper filters placed in glass funnels.

Glass tubes for stirring and mixing corrosive liquors; spatulas of wood, ivory, metal, and of glass.

Thin pasteboards, and horns, very convenient for collecting matters bruised with water upon the levigating stone, or in mortars; corks of all sizes; bladders and linen strips for luting vessels.

A good portable pair of bellows; a good steel for striking fire; a glue pot, with its little brush; lastly, a great many boxes of various sizes, for containing most of the above-mentioned things, and which are to be placed upon the shelves.

Besides these things, some substances are so necessary in most chemical operations, that they may be considered as instruments necessary for the practice of this science. These substances are:

All metals and semi-metals, which ought to be very pure.

Vitriolic acid, some of which ought to be concentrated and rectified, and also some of that sort commonly sold by druggists.

Aqua fortis, such as is commonly sold, and is cheap; also spirit of nitre moderately strong, but very pure: the same acid very pure, concentrated, and smoking.

Common spirit of salt, some of the same acid very pure, very strong, and smoking. All these acids ought to be kept in crystal glass bottles, and closed with glass stoppers.

Some distilled vinegar, which may be kept in an ordinary bottle; some radical vinegar, which ought to be kept in a bottle with a glass stopper; some cream of tartar, in an earthen or glass vessel, or in a box.

Common fixed vegetable alkali, very dry, such as pot ash, which must be kept in a well closed bottle. The same alkali in a liquid state.

Very pure salt of tartar, some dry, and some liquid.

Mineral alkali, liquid; that is, a solution of soda. The same alkali dry and very pure; that is, well formed crystals of soda.

The two fixed alkalis liquid, and rendered caustic by quick-lime. Alkalis, particularly those which are caustic, ought to be kept in bottles with glass stoppers. Some phlogisticated fixed alkali, or even saturated, so as to be fit for making Prussian blue.

Some dry liver of sulphur kept in a well closed bottle. The same liquid. Some common sulphur.

Very pure alkali of sal-ammoniac, disengaged by a fixed alkali, some solid, and some liquid, kept in a bottle with a glass stopper.

Volatile alkali from sal-ammoniac disengaged by quick-lime, as strong as is possible. Some of this may be kept of less strength.

Lime water, and quick-lime, in well closed bottles.

The purest and highest rectified spirit of wine.

Good vitriolic ether.

Rectified essential oil of turpentine; oil of olives; soap.

Galls; syrup of violets; tincture of turnsol, or turniol in rags; fine blue paper; river or distilled rain-water.

Besides these substances, most of which are solvents, certain neutral salts ought to be had which are frequently used in chemical operations, or are difficultly prepared. These are:

Vitriolated tartar; alum, and calcined alum; green vitriol; blue vitriol; nitre; decrepitated common salt; some of the same salt very pure, dissolved in distilled water; purified sal-ammoniac; calcined borax; sedative salt.

A pure solution of silver in spirit of nitre; a solution of mercury in the same acid; butter of antimony. All these to be kept in bottles with glass stoppers. Corrosive sublimate.

Cerufs; letharge; minium; sand washed and ground; white marble; washed chalk; glass of lead; glass of borax.

A person provided with the above-mentioned instruments and substances may at once perform any chemical experiment. He may indeed occasionally want several neutral salts which have not been named; but all these salts with bases of earths, metals, fixed or volatile alkalis, may be easily and instantly prepared, as most of them do not require distillation or sublimation. They may nevertheless, if they are not too numerous, be all previously prepared and kept ready for any occasion.

The general observations of Macquer upon the conducting of chemical processes are truly valuable and judicious. Method, order, and cleanliness, are essentially necessary in a chemical laboratory. Every vessel and utensil ought to be well cleansed as often as it is used, and put again into its place: inscriptions ought to be fastened upon all the substances. These cares, which seem to be trifling, are however very fatiguing and tedious; but they also are very important, though frequently little observed. When a person is keenly engaged, experiments succeed each other quickly; some seem nearly to decide the matter,

and others suggest new ideas: he cannot but proceed to them immediately, and he is led from one to another: he thinks he shall easily know again the products of the first experiments, and therefore, he does not take time to put them in order: he prosecutes with eagerness the experiments which he has last thought of; and in the mean time, the vessels employed, the glasses and bottles filled, so accumulate, that he cannot any longer distinguish them; or at least, he is uncertain concerning many of his former products. This evil is increased if a new series of operations succeed, and occupy all the laboratory; or if he is obliged to quit it for some time: every thing then goes into confusion. Thence it frequently happens that he loses the fruits of much labour, and that he must throw away almost all the products of his experiments.

The only method of avoiding these inconveniences is to employ the cares and attentions above-mentioned. It is indeed disagreeable to stop continually in the middle of the most interesting researches, and to employ a very precious and considerable time in cleaning vessels, arranging them, fastening inscriptions on them, &c. These employments are capable of cooling or retarding the progress of genius, and are tedious and disgusting; but they are nevertheless necessary. Those persons whose fortune enables them to have an assistant operator, on whose exactness and intelligence they can depend, avoid many of these disagreeable circumstances; but they ought nevertheless to attend to the execution of these things. We cannot depend too much on ourselves in these matters, however minute, on account of their consequences. This becomes even indispensable when the experiments are to be kept secret, at least for a time; which is often necessary in chemistry.

When new researches and inquiries are made, the mixtures, results, and products of all the operations ought to be kept a long time, distinctly labelled and registered; for these things, when kept some time, frequently present phenomena that were not at all suspected. Many fine discoveries in chemistry have been made in this manner, and many have certainly been lost by throwing away too hastily, or neglecting the products.

It cannot be too much recommended to chemical operators to be exceedingly upon their guard against imposing and deceitful experiments, which frequently present themselves in practice. A circumstance seemingly unimportant, or not easily perceptible, is frequently sufficient to give the appearance of a great discovery, by means of certain effects, which, nevertheless, are found to proceed from some other cause. Chemical experiments depend on so many accessory things, that all of them can seldom be attended to, particularly when the subject is new: hence we frequently find that very different results proceed from the same experiments, and at different times. We therefore must not decide after the first success; but the experiment must be repeated several times, and even varied, till no doubt can remain.

Since chemistry offers many views for the improvement of many important arts; as it presents prospects of many useful and profitable discoveries; those who apply their labours in this way ought to be exceedingly circumspect not to be led into an useless expence of money and time. Those researches which have some analogy with the philosopher's stone, from the hopes of wealth which they suggest, are also attended with similar danger. In a certain set of experiments some one is generally of an imposing appearance, although in reality it be nothing more. Chemistry is full of these half successes, which serve only to deceive the unwary, to multiply the number of trials, and to lead to great expence before the

the fruitlessness of the search be discovered. By these reflections we do not intend to divert from all such researches those whose taste and talents render them fit for them; on the contrary, we acknowledge that the improvement of the arts, and the discovery of new objects of manufacture and commerce, are undoubtedly the finest and most interesting part of chemistry, and which make that science truly valuable; for without these ends what would chemistry be but a science purely theoretical, and capable of employing only some abstract and speculative minds, but useless to society? We acknowledge also, that the successes in this kind of chemical inquiry are not rare; and that their authors have sometimes acquired fortunes, so much the more honourable as being the fruits of their talents and industry. But we repeat, that, in these researches, the more dazzling and near any success appears, the more circumspection, and even distrust is necessary. *See ANALYSIS, APPARATUS, ATTRACTION, BALANCE, BLOW PIPE, FORGE FURNACE.*

LABRADOR STONE. A beautiful stone from the coast of Labrador. Its colour is commonly of a light, or of a deep gray, frequently blackish; but when held in certain positions to the light, it exhibits varieties of beautiful internal colours, chiefly consisting of shades of blue and green, seldom yellow, in some parts of a copper red, and violet. These colours have for the most part a slaky or spotted appearance, but sometimes they lie in stripes.

These stones are found of an angular form in pieces of considerable magnitude, their specific gravity is 2.755, their fracture is laminated; the broken parts are rhomboidal, and semi-transparent. In other respects this stone agrees with the felt spar, but is softer.

LAC, or LACCA. Is a substance well known in Europe, under the different appellations of stick-lac, shell-lac, and seed-lac. The first is the lac itself, which is a brown semi-transparent substance, in pretty considerable lumps, with woody parts adhering to it. Seed-lac is the stick-lac broken in pieces, and appearing in a granulated form. Shell-lac is the substance which has undergone a simple purification.

Lac is the product of an insect*, which deposits its eggs on the branches of a tree called Bihar, in Assam, a country bordering on Thibet, and elsewhere in India. It appears designed to answer the purpose of defending the eggs from injury, and affording food for the maggot in a more advanced state. It is formed into cells, finished with as much art and regularity as an honey-comb, but differently arranged; and the inhabitants collect it twice a year, in the months of February and August. For the purification, it is broken into small pieces, and put into a canvas bag of about four feet long, and not above six inches in circumference. Two of these bags are in constant use, and each of them held by two men. The bag is placed over a fire, and frequently turned, till the lac is liquid enough to pass through its pores; when it is taken off the fire, and twisted in different directions by the men who hold it, at the same time dragging it along the convex part of a plantain tree prepared for that purpose; and while this is doing, the other bag is heating, to be treated in the same way. The mucilaginous and smooth surface of the plantain tree prevents its adhering; and the degree of pressure regulates the thickness of the coating of lac, at the same time that the fineness of the bag determines its clearness and transparency.

Lac is not entitled to arrangement either with oils, resins, or gums. It is

* For a description, consult Kerr, in the Phil. Transf. vol. lxxi. p. 374.

not soluble either in water, or in fat oils. Some essential oils appear to extract a dilute tincture. The action of the acids upon lac, either when concentrated or diluted, does not seem to be considerable; but this requires more particular examination; especially as far as relates to the nitrous acid. Ardent spirit acts but feebly on this substance. By standing upon it in the cold, it forms a clear tincture, apparently by dissolving only a part of its principles; but, when digested in a moderate heat, the whole of the lac unites with the spirit, and forms a turbid mixture, or imperfect solution, of a gummy appearance, which does not afterwards become clear. In this way, however, with judicious management, it appears practicable to form a very hard opaque varnish, resembling that of China or Japan. The principal use of lac is in the manufacturing of sealing-wax, and in dyeing scarlet. For this last purpose, half a dram of powdered comfrey root is to be boiled in a quart of water for a quarter of an hour, and some powdered gum lac digested in the decoction for two hours. The tincture appears of a fine crimson colour; and the remaining lac, if the quantity of liquor has been sufficient, is of a pale straw colour. The clear tincture being then poured off, and a solution of alum gradually added, the colouring matter subsides, in the form of one of the powders called lakes, which amounts to about one-fifth part of the weight of the lac. This fecula is dissolved in warm water, with the addition of a proper quantity of the solution of tin in aqua regia: and the liquor, which is of a fiery red colour, is then to be poured into boiling water, impregnated with salt of tartar, or the mild fixed vegetable alkali. The bath, thus formed, is a good scarlet dye for woollens, though less lively than that of cochineal.

LACQUER. See VARNISH.

LAKE. This term is used to denote a species of colours formed by combining the earth of alum, or calx of tin, with the colouring matter of certain vegetables. The principal lakes are, Carmine, Florence-lake, and lake from Madder.

For the preparation of *Carmine*, four ounces of finely pulverized cochineal are to be poured into four or six quarts of rain or distilled water, that has been previously boiled in a pewter kettle, and boiled with it for the space of six minutes longer; (some advise to add, during the boiling, two drachms of pulverized crystals of tartar). Eight scruples of Roman alum in powder, are then to be added, and the whole kept upon the fire one minute longer. As soon as the gross powder has subsided to the bottom, and the decoction is become clear, this latter is to be carefully decanted into large cylindrical glasses covered over, and kept undisturbed, till a fine powder is observed to have settled at the bottom. The superincumbent liquor is then to be poured off from this powder, and the powder gradually dried. From the decanted liquor, which is still much coloured, the rest of the colouring matter may be separated by means of the solution of tin, when it yields a carmine little inferior to the other.

For the preparation of *Florentine lake*, the sediment of cochineal that remained in the kettle, may be boiled with the requisite quantity of water, and the red liquor likewise that remained after the preparation of the carmine, mixed with it, and the whole precipitated with the solution of tin. The red precipitate must be frequentlyedulcorated with water. Exclusively of this, two ounces of fresh cochineal, and one of crystals of tartar, are to be boiled with a sufficient quantity of water, poured off clear, and precipitated with a solution of tin, and the precipitate washed. At the same time two pounds of alum are also to be dissolved in

in water, precipitated with a lixivium of pot-ash, and the white earth repeatedly washed with boiling water. Finally, both precipitates are to be mixed together in their liquid state, put upon a filter, and dried. For the preparation of a *cheaper* sort, instead of cochineal, one pound of Brazil wood may be employed in the preceding manner.

Madder lake, which was mentioned long ago by Neri, and has been since discovered afresh by Margraff, is made by dissolving two ounces of Roman alum in six pounds of boiling water, and to this adding two ounces of fine madder, with which the water is suffered to boil once or twice more, and then to stand for some time in digestion. The decoction being afterwards filtered, a solution of alkali is to be mixed with it till no farther precipitation ensues.

LAMP. See LIGHT.

LAMP BLACK. When the parts of organized substances which are of an inflammable nature are burning under circumstances wherein a complete combustion does not take place, part of the coaly matter is carried up through the flame, and forms soot. Common soot contains other matters besides charcoal: but the soot of oily substances is considerably pure. The finest lamp-black is actually produced by collecting the smoke from a lamp with a long wick, which supplies more oil than can be perfectly consumed, or by suffering the flame to play against a metalline cover, which impedes the combustion not only by conducting off part of the heat, but by obstructing the current of air. Lamp-black, however, is prepared in a much cheaper way, for the demands of trade. The dregs which remain after the eliquation of pitch, or else small pieces of fir-wood, are burned in furnaces of a peculiar construction, the smoke of which is made to pass through a long horizontal flue, terminating in a close boarded chamber. The roof of this chamber is made of coarse cloth, through which the current of air escapes, while the soot remains behind. See LIGHT.

LAPIS HEPATICUS. A stone of a white, grey, yellow, brown, or black colour; it is generally compact, but not so hard as to give fire with steel; of a texture either equable or laminar, scaly or sparry, and which takes a polish as alabaſter.

It does not effervesce with acids. When calcined, it is partially reduced to a sort of Plaster of Paris. It emits a smell of hepar sulphuris, at least when rubbed. According to Bergman, 100 parts of it afford 33 of baroselenite, 38 of silex, 22 of alum, 7 of gypsum, and 5 of mineral oil. The increase proceeds from the water of crystallization.

LAPIS INFERNALIS. See INFERNAL STONE.

LAPIS LAZULI. The colour of this stone is a beautiful opaque blue, which varies a little in intensity, and is generally sprinkled over with yellow, bright, pyritaceous specks or streaks: it obstinately retains its colour in a strong heat, which distinguishes it from other blue stones: it is of an equable or very fine granular texture, and takes a beautiful polish: its specific gravity is 3.054.

If powdered and not calcined, it effervesces very slightly with acids; but if calcined, it does not effervesce, but becomes gelatinous.

In a strong fire it melts without addition into a whitish glass. From the experiments of Cronstedt and Margraff this stone does not appear to contain copper. The latter found lime, vitriolic acid, iron, and silex; Rinman has since discovered it to contain the acid of spar. If the colour be owing to the iron, we are still unacquainted with the modification by which it remains permanent in a strong heat.

LAPIS

LAPIS LYDIUS. A variety of the trapp of the Swedes; its colour is black, and it is well known by the name of the touch-stone. The black basalt, from which this stone scarcely differs in its component parts, is used for the same purpose. See **ASSAY**.

LAPIS NEPHRITICUS. See **JADE**.

LAPIS OBSIDIANUS. The lapis obsidianus of Pliny appears to have been a volcanic product, resembling the black basalt, but in a higher state of vitrification.

LAPIS OLLARIS, or soap rock. A stone of the magnesian genus, of a yellow colour, sometimes whitish, and but rarely black. It is easily wrought and turned, so that pots and mortars are often made of it.

LAPIS SPECULARIS. A name given to the transparent gypseous spar, or combination of vitriolic acid and lime.

LAPIS SUILLUS. See **LAPIS HEPATICUS**.

LAVA. See **VOLCANIC PRODUCTS**.

LAUDANUM. See **OPIMUM**.

LAZULI, LAPIS. See **LAPIS LAZULI**.

LEAD. Is a white metal, of a considerably blue tinge, very soft and flexible, not very tenacious, and consequently incapable of being drawn into fine wire, though it is easily extended into thin plates under the hammer. Its weight is very considerable, being rather greater than that of silver. Long before ignition, namely at about the 540th degree of Fahrenheit's thermometer, it melts; and then begins to be calcined, if respirable air be present. In a strong heat it boils, and emits fumes; during which time, if exposed to the air, its calcination proceeds with considerable rapidity. If melted lead be poured into a box previously rubbed with chalk to prevent its action on the wood, and be continually agitated, it will concrete into separate grains, of considerable use in various mechanical operations, particularly that of weighing. Lead is brittle at the time of congelation. In this state it may be broken to pieces with a hammer, and the crystallization of its internal parts will exhibit an arrangement in parallel lines.

This metal, during the progress of heat, first becomes converted into a dusky powder, which by a continuation of the heat becomes white, yellow, and afterwards of a bright-red, inclining to orange colour, called minium, or red lead. The process requires considerable management with regard to the heat, and access of the air in the making of red lead. Many days are required for this purpose. If the heat be too great or rapid, the lead becomes converted into a flaky substance, called litharge; and a still greater heat converts it into a clear, transparent, yellow glass, which powerfully dissolves and corrodes metallic calces or earths; and on this account it usually finds its way through the crucibles in a short time. It acts more difficultly on argillaceous than on siliceous earths; whence it is found, that vessels made of clay mixed with broken pottery, are preferable to those that are composed of clay and sand. The calx of lead is a principal ingredient in most of the modern fine white glasses. It is more particularly calculated to form the dense glass used to correct the aberration arising from colour in those telescopes, which are known by the name of achromatic; because it communicates the property of separating the coloured rays from each other, in greater angles than obtained in alkaline glasses at equal angles of mean refraction. See **ACHROMATIC**, also **GLASS**. The imperfection which most considerably affects this kind of glass is, that its density is

seldom uniform throughout. The irregularities shew themselves in the form of veins, which greatly disturb the regular refraction.

Lead is not much altered by exposure to air or water, though the brightness of its surface, when cut or scraped, very soon goes off. It is probable that a thin stratum of calx is formed on the surface, which defends the rest of the metal from corrosion.

Most of the acids attack lead. The vitriolic acid does not act upon it, unless it be concentrated and boiling. Vitriolic acid air escapes during this process, and the acid is decomposed. When the distillation is carried on to dryness, a saline white mass remains, a small portion of which is soluble in water, and is the vitriol of lead: it affords crystals. The residue of the white mass is a calx of lead.

Nitrous acid acts strongly on lead, and converts it into a white calx, if the acid be concentrated; but if it be more diluted, the calx is dissolved, and forms a nitre of lead which is crystallizable, and does not afford a precipitate by cooling. It detonates on ignited coals. Lime and alkalis decompose the nitrous solution of lead. The vitriolic acid added to this solution combines with the metallic calx, and falls down. The marine acid in the same manner carries down the lead, and forms a combination called *plumbum corneum*, which is more soluble in water than the horn silver.

Marine acid acts directly on lead by heat, which it calcines, and dissolves part of its calx. The marine salt of lead is crystallizable.

The acetous acid dissolves lead and its calces; though probably the access of air may be necessary to the solution of the metal itself in this acid. White lead, or ceruse, is made by rolling leaden plates spirally up, so as to leave the space of about an inch between each coil, and placing them vertically in earthen pots, at the bottom of which is some good vinegar. The pots are to be covered, and exposed for a length of time to a gentle heat in a sand bath, or by bedding them in dung. The vapour of the vinegar, assisted by the tendency of the lead to combine with the pure part of the air which is present, corrodes the lead, and converts the external portion into a white calx, which comes off in flakes, when the lead is uncoiled. The plates are thus treated repeatedly until they are corroded through. Ceruse is the only white substance used in oil paintings. It may be dissolved without difficulty in the acetous acid, and affords a crystallizable salt, called sugar of lead from its sweet taste. This, like all the preparations of lead, is a most deadly poison.

Liver of sulphur precipitates lead from its solutions, the sulphur falling down in combination with the lead. Pure alkaline solutions dissolve a small portion of lead, and corrode a considerable quantity: the solution is said to give a black colour to the hair.

Oils dissolve the calces of lead, and become thick and consistent; in which state they are used as the basis of plasters, cements for water works, paints, &c.

In the dry way, lead alone is calcined and vitrified. When fused with fixed alkaline salts, it is converted into a dark-coloured scoria, partly soluble in water. The neutral salts in general are not acted upon by lead. Nitre calcines this metal when treated with it, though scarcely any commotion or apparent flame is produced by its action. Sulphur readily dissolves it in the dry way, and produces a brittle compound, of a deep gray colour and brilliant appearance, which is much less fusible than lead itself, a property which is common to all the combinations of sulphur with the more fusible metals.

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The phosphoric acid, exposed to heat together with charcoal and lead, becomes converted into phosphorus, which combines with the metal. This combination does not greatly differ from ordinary lead; it is malleable, and easily cut with a knife; but it loses its brilliancy more speedily than pure lead; and when fused upon charcoal with the blow-pipe, the phosphorus burns, and leaves the lead behind.

Lead decomposes sal ammoniac by the assistance of heat; its calces unite with the marine acid of that salt in the cold, and disengage its volatile alkali. When volatile alkali is obtained by distilling sal ammoniac with the calces of lead, the residue consists of plumbum corneum.

Litharge fused with common salt decomposes it; the lead unites with the marine acid, and forms a yellow compound, at present used in this country as a pigment, for which an exclusive privilege has been granted. The alkali either floats at top, or is volatilized by the heat, if strongly urged. The same decomposition takes place in the humid way, if common salt be macerated with litharge; and the solution will contain caustic alkali.

Lead unites with most of the metals. Gold and silver are dissolved by it in a slight red heat. Both these metals are said to be rendered brittle by a small admixture of lead, though lead itself is rendered more ductile by a small quantity of them. Platina forms a brittle compound with lead; mercury amalgamates with it; but the lead is separated from the mercury by agitation, in the form of an impalpable black powder, vital air being at the same time absorbed. The presence of vital air is indispensably necessary in this process. Copper and lead do not unite but with a strong heat. If lead be heated so as to boil and smoke, it soon dissolves pieces of copper thrown into it; the mixture when cold is brittle. The union of these two metals is remarkably slight; for upon exposing the mass to a heat no greater than that in which lead melts, the lead almost entirely runs off by itself. This process, which is peculiar to lead with copper, is called eliquation. The coarser sorts of lead, which owe their brittleness and granulated texture to an admixture of copper, throw it up to the surface on being melted by a small heat. Iron does not unite with lead, as long as both substances retain their metallic form. Tin unites very easily with this metal, and forms a compound which is much more fusible than lead by itself, and is for that reason used as a solder for lead. Two parts of lead and one of tin form an alloy more fusible than either metal alone: this is the solder of the plumbers. Bismuth combines readily with lead, and affords a metal of a fine close grain, but very brittle. A mixture of eight parts bismuth, five lead, and three tin, will melt in a heat which is not sufficient to cause water to boil. Regulus of antimony forms a brittle alloy with lead. Wolfram unites with it into a spongy ductile compound, which splits into leaves when hammered. Nickel, cobalt, manganese, and zinc, do not unite with lead by fusion.

All the calces of lead are very easily revived. Minium, when exposed to a strong heat, gives out part of the vital air it absorbed during its calcination; but, like the other calces of this metal, it requires the addition of some combustible substance for its complete revival. A familiar instance of this revival is seen by exposing the common wafers to the flame of a candle. These wafers are coloured with minium, which is revived by the heat and inflammable substance of the wafer, so that it falls down in metallic globules.

Lead is found native, though seldom; and also in the form of a calx, called native ceruse, or lead ochre, or lead spar of various colours, red, brown, yellow, green, blueish, and black. These ores, when freed as much as possible from earthy

earthy matter, may be dissolved in diluted nitrous acid. Calx of iron is usually thrown down from the solution by boiling. If the lead be then precipitated by the mild mineral alkali, and weighed, 132 grains of the dry precipitate will correspond with 100 grains of lead in the metallic state. If the precipitate be suspected to contain copper, it may be separated by digesting in volatile alkali. If it be supposed to contain silver and copper, the precipitate may again be dissolved in nitrous acid, and separated by the addition of marine acid; which combining with the metal, produces *luna cornea*, and *plumbum corneum*; the latter of which, being soluble in 30 times its weight of boiling water, may be washed off, while the silver remains undissolved; or the silver, if alone in the precipitate, may be taken up by volatile alkali, which will leave the calx of lead of the same value with regard to weight as the foregoing. Lead is also found mineralized by the vitriolic and the phosphoric acids: this last is of a greenish colour, arising from a mixture of iron. The vitriol of lead is soluble in about 18 times its weight of water. One hundred and forty-three grains of the dried salt represent 100 grains of lead. The phosphoric lead ore may be dissolved in nitrous acid by means of heat, except a few particles of iron, which remain at the bottom. By the addition of vitriolic acid, the lead is thrown down in the form of white flakes of vitriol, which when washed and dried, discover the quantity of lead they contain, by the same allowance of 143 grains of the salt to 100 grains of metallic lead. The remaining solution being evaporated to dryness, affords phosphoric acid.

Lead is abundantly found in combination with sulphur, in the form of heavy, shining, black, or blueish lead-coloured cubical masses, whose corners are usually truncated; its texture is laminated, and its hardness variable. This is called *galina*, or potters lead ore. Most lead ores contain more or less of silver. When antimony enters into its composition, the texture is radiated or filamentous. There are also lead pyrites, which contain a considerable proportion of iron and sulphur; and red lead spar, which consists of lead mineralized by sulphur and arsenic; this is very scarce.

If sulphurated lead be boiled in nitrous or marine acid of a moderate strength, the sulphur may be obtained pure, and collected in a filter. When iron or stony particles are contained among the undissolved part, the sulphur may be separated by digestion in a solution of caustic fixed alkali, which converts it into liver of sulphur, and leaves the other insoluble matters behind. If the first solution be made with nitrous acid, it may contain silver and lead, which, after the precipitation by mild mineral alkali, may be separated by the volatile alkali, as mentioned in the humid analysis of the calciform ores: when the marine acid is used for the solution of the ore, a large quantity of *plumbum corneum* separates, for want of a sufficient quantity of water to dissolve it. This requisite quantity of water must be added to dissolve the salt, before the precipitate is made by the fixed alkali.

All the ores of lead, except the phosphoric, are reducible to the metallic state, by dissipating their volatile contents by the blow-pipe on a piece of charcoal. In the large way, they are revived by fusion with charcoal.

The ores of this metal are abundantly found in the mine counties of England, and in various other parts of the globe. Its uses are numerous, and scarcely need be mentioned. Its calces have been already mentioned as of great use, as a pigment, and in the manufacture of glass. Lead is cast into thin sheets for cover-

ing buildings, making water pipes, and various other uses; and this is rolled between two cylinders of iron, to give it the requisite uniformity and thinness. Lead is thought, and with some reason, to be not perfectly innocent even for water pipes, and much less for any other kind of vessels. The workmen in any of the preparations of lead are generally subject to a peculiar cholic, and paralytic disorders; which most probably arise from the internal use of the metal: for it is a fact that these workmen are not sufficiently cautious in washing their hands, or removing such particles of lead, or its preparations, as may casually intermix with their food.

LEATHER. The skins of animals prepared by maceration in lime-water, and afterwards with astringent substances. See **TANNING**.

LEAVES OF PLANTS. Lewis found * that the green colour of the leaves of plants is extracted by rectified spirit, and by oils. The spirituous tinctures are generally of a fine deep green, even when the leaves are dull coloured, yellowish, or hoary. These colours are seldom lasting in the liquor. Alkalis heighten both the tinctures and the green juices. Acids weaken, destroy, and change it to a brownish. Lime-water improves both the colour and durability. By means of lime, not inelegant green lakes are procurable from the leaves of acanthus, lily of the valley, and several other plants.

Few plants communicate any part of their green colour to water, and perhaps none that give a green of any considerable intensity. It is said, however, that the leaves of some plants give a green dye to woollen, without the addition of any other colouring matter; particularly those of the wild chervil, or cow-weed, the common rag-wort and devil's bit. Lewis gives the process from Linnæus as practised by the peasants in Sweden with this last. It consists in boiling the leaves with their woollen yarn for a short time, and leaving the whole together for a night, after which the yarn is taken out, and hung in the steam of the liquid, again made to boil over the fire. It is then wrung, the leaves are taken out of the liquor, a little fresh water added, and the wool frequently dipped therein till sufficiently dyed.

Many kinds of leaves afford a yellow dye to woollens previously boiled with alum and tartar, weld in particular, which see. Indigo and woad afford blue. Lewis tried, without success, to obtain blues by macerating the leaves of other plants in water.

LEES, SOAP. See **ALKALI FIXED**. Also **SOAP**.

LEMNIAN EARTH. See **EARTH, FULLERS**.

LEMONS. The juice of lemons, or limes, has all the characters of an acid of considerable strength. On account of the mucilaginous matter with which it is mixed in its first state, it is very soon altered by spontaneous decomposition. Various methods have been contrived to prevent this effect from taking place, in order that this wholesome and agreeable acid might be preserved for use in long voyages, or other domestic occasions. The juice may be kept in bottles under a thin stratum of oil, which indeed prevents, or greatly retards, its total decomposition; though the original fresh taste soon gives place to one which is much less grateful. In the East Indies it is evaporated to the consistence of a thick extract. If this operation be carefully performed by a very gentle heat, it is found to be very effectual. When the juice is thus heated, the mucilage

* On Neumann, ii. 236.

thickens,

thickens, and separates in the form of flocks; part of which subsides, and part rises to the surface: these must be taken out. The vapours which arise are not acid. If the evaporation be not carried so far as to deprive the liquid of its fluidity, it may be long preserved in well closed bottles; in which, after some weeks standing, a farther portion of mucilage is separated, without any perceptible change in the acid.

Of all the methods of preserving lemon juice, that of concentrating it by frost appears to be the best; though, in the warmer climates, it cannot conveniently be practised. Lemon juice, exposed to the air in a temperature of between 50° and 60°, deposits in a few hours a white semi-transparent mucilaginous matter, which leaves the fluid, after decantation and filtration, much less alterable than before. This mucilage is not of a gummy nature, but resembles the gluten of wheat in its properties: it is not soluble in water, when dried. More mucilage is separated from lemon juice by standing in closed vessels. If this depurated lemon juice be exposed to a degree of cold of about seven or eight degrees below the freezing point, the aqueous part will freeze, and the ice may be taken away as it forms; and if the process be continued until the ice begins to exhibit signs of acidity, the remaining acid will be found to be reduced to about one-eighth of its original quantity, at the same time that its acidity will be eight times as intense; as is proved by its requiring eight times the quantity of alkali to saturate an equal portion of it. This concentrated acid may be kept for use; or, if preferred, it may be made into a dry lemonade, by adding six times its weight of fine loaf sugar in powder*.

The above processes may be used when the acid of lemons is wanted for domestic purposes; because they leave it in possession of the oils, or other principles, on which its flavour peculiarly depends. But in chemical researches, where the acid itself is required to be had in the utmost purity, a more elaborate process must be used. Boiling lemon juice is to be saturated with powdered chalk, whose weight is to be noted. The neutral saline compound is scarcely more soluble in water than selenite: it therefore falls to the bottom; while the mucilage remains suspended in the watery fluid, which must be decanted off. The remaining precipitate must then be washed with warm water until it comes off clear. To the powder, thus edulcorated, a quantity of vitriolic acid, sufficient to saturate the chalk, and diluted with ten parts of water, must be added, and the mixture boiled a few minutes. The vitriolic acid combines with the lime, and forms selenite, which remains behind when the cold liquor is filtered; while the disengaged acid of lemons remains dissolved in the fluid. This last must be evaporated to the consistence of a thin syrup; and vitriolic acid must then be added in small portions, to precipitate the lime, if any should still remain in combination with acid of lemons. When no more precipitate is afforded by the addition of vitriolic acid, a farther evaporation separates the pure acid of lemons in crystals. It is necessary that the vitriolic acid last added should be rather in excess; because the presence of a small quantity of lime will prevent the crystallization. This excess will be found in the mother water†.

The concrete acid of lemons remains consistent in the air, is very soluble in water, and exhibits strong acid properties. Its watery solution is decomposed by a slow putrefaction. It unites with the alkalis and earths, silex excepted; and

* Georgius, quoted by Fourcroy, iv. 33.

† Schede's Essays, Eng. translation, p. 361; or Crell's Journal for 1784.

forms peculiar neutral salts, which have not yet been much examined. Several of the metallic substances are likewise acted upon by it; and it would probably dissolve all their calces.

LEVIGATION. The mechanical process of grinding the parts of bodies to a fine paste, by rubbing the flat face of a stone called the muller upon a table or slab called the stone. Some fluid is always added in this process, which circumstance, together with the difference of the instruments, appears to constitute the distinction between this process and trituration, which last is performed in a mortar upon powder, either dry or wetted. The advantage of levigation with a stone and muller, beyond that of trituration in a mortar, is, that the materials can more easily be scraped together, and subjected to the action of the muller, than in the other case to that of the pestle.

LIGHT. Philosophers are not agreed as to the independent existence of light, or the cause by which we see; that is to say, whether light be a body, or a property. If light be a body, it must consist of particles of extreme minuteness, projected with a very great degree of velocity from luminous bodies; if on the other hand light be nothing more than a modification or property, it must subsist in some other matter universally diffused through every part of known space. The philosophers who maintain this last opinion, consider the universe to be occupied by a fluid of extreme rarity and elasticity, permeating all bodies; the undulations of which, transmitted in all directions, from the luminous body, or exciting cause, produce the sensation and other effects of light. Though much ingenious reasoning has been employed on this subject, we have not obtained possession of any decisive facts; but each hypothesis may without inconsistency be applied to every natural appearance hitherto observed. It is difficult, however, to speak of these facts, without considering light according to one or the other of these suppositions. This is not the place for discussing their respective merits. I shall therefore assume the hypothesis which admits of the independent existence of light, not only because it is more generally admitted and known, but because it appears best calculated to explain some of the appearances, more especially the various refrangibility of the rays of light.

It is observed that whenever light passes through a space occupied by a medium of uniform density, it describes a right line. These lines, or rather prisms, are called the rays of light. They rebound, or are reflected by bodies against which they strike. It is sufficiently ascertained that this reflection is caused by a repulsive power in the body itself, exerted at a considerable distance; so that the light is driven back without coming into contact with the matter which repels it. When light is made to pass near a body in such a direction, or under such circumstances, as that it may come nearer than the limit of repulsion, it is attracted, and alters its course by deviating towards the attracting body. If the body possesses a very narrow surface, such for example as the edge of a knife, this deviation in the ray of light may be measured by attending to the course of the ray after it has passed the body. But if the surface be broader, the attractive power usually causes the light to pass into the body, where it is absorbed and lost, if the body be opaque, or passes through, if the body be transparent. The change produced in the course of a ray of light, by the attraction of a body into which the light does not enter, is called inflexion; but when the light does enter the body, this change is called refraction. It is found that the light of the sun from which we derive the sensation of whiteness is composed of an admixture of rays possessing the property of exciting sensations of every possible colour, each according to its
respective

respective nature. The attractive and repulsive powers of bodies differ in their intensities with regard to these several rays, and accordingly they are separated from each other by reflection, refraction, or inflection. A like separation is also made in the rays of light by the thickness or distance between the two surfaces of the medium through which they pass. It is more particularly observable in thin plates of glass, or water blown into bubbles, and the like. The colours of bodies depend on a power possessed by them of reflecting some of the rays of light, and absorbing others, and this power in all probability depends upon the principles here sketched out.

The velocity of light is so extremely great, that in all common experiments it appears to be instantaneous. Astronomers have nevertheless found that its progress across the regions occupied by the solar system requires so much time, that in computing the eclipses of Jupiter's moons, they are under the necessity of making an allowance for the greater or less distance of that planet, which occasions the time of any eclipse to be later when seen from a greater distance than from a less. Other observations upon the fixed stars shew that there is a sensible proportion between the velocity of light, and that of the earth in its annual orbit. From these acute investigations, it is deduced that light passes from the sun to the earth in little more than eight minutes, which gives a velocity of about 167000 geographical miles in one second.

Optical writers may be consulted for a great number of curious and useful deductions made from these principles, and applied to the doctrine of vision, the nature of colours, the construction of mirrors, telescopes, and other instruments, not immediately within the province of chemistry.

Light comes to our eyes under six different circumstances. 1. It is emitted from bodies in a rapid state of combustion: or, 2. from other bodies at an elevated temperature, which are then said to be ignited. 3. It also comes to us by 4. reflection; or 5. refraction: and 6. there are very few bodies which being exposed to a strong light, and afterwards taken into the dark, do not remain luminous for a considerable time. Hence it seems that we experimentally know of no other source of light, than combustion; and from this fact it is that many writers have considered fire, heat and light, to be the same thing. But these objects differ in various remarkable particulars. The heat of a fire is by no means proportional to the light it gives. The light will pass through transparent bodies swiftly, and without impediment, but the heat remains attached to the body, and is not transmitted in any other way, than it would have passed through an opaque substance, viz. by raising the temperature of the body itself. Heat, with access of pure air, causes bodies to be burned, and to lose their combustible property. Light in many instances produces a contrary effect. The effect of light in chemical experiments is so considerable, that the operator ought to be constantly aware of the influence it may have upon his products. It appears to be particularly active in disengaging vital air from its combinations; but whether by uniting with the air, or otherwise, has not been explained. Every chemist knows that pure pale nitrous acid cannot be preserved but in bottles quite full, or in the dark. For the light expels vital air from the acid, if there be any space into which it can escape, and leaves the residue yellow and fuming, in consequence of the redundant portion of the basis of the acid. Mere heat is so far from effecting this, that it restores the purity of the acid by expelling the redundancy. So likewise the black calx of manganese, which contains phlogisticated air and vital air, emits the former at a low heat, but does not give out the latter until light be present

present by the ignition of the vessels. Light appears to be the great agent in the production of combustible matter on the surface of the globe. It extricates vital air from the leaves and other parts of vegetables, most probably by decomposing their aqueous part, and leaves the combustible matter, or inflammable air which enters into the composition of mucilages, oils, and resins, the most inflammable of which are the products of such climates as possess the greatest intensity of solar light. The consequences of a want of light in vegetation, are remarkably shewn in the properties and chemical products of plants of the same kind, reared in the open day, or in the dark. The tendency of plants growing in a room, which turn themselves towards the aperture which admits the light, or even towards the thinnest side of a wooden box wherein they are included, is a striking effect, and has been ascribed to a degree of sensibility in these organized beings. But the evaporation of camphor and of water, the vegetation and crystallization of salts, and of metallic substances, which are considerably modified by light, and incline themselves towards the place of its emission, seem to be instances of the same kind. The metallic calces, and the salts produced by the aerated marine acid, undergo a change by the action of light, rendering them nearer the state of combustibility than before.

Whence comes the light afforded by ignited bodies; whether it has been previously imbibed by them; whether the commencement of ignition be distinctive of the same temperature in all bodies; whether the great planetary sources of light be bodies in a state of combustion, or merely luminous upon principles very different from any which our experiments can point out; whether the momentum of the particles of light, or their disposition for chemical combination be the most effectual in the changes produced by its agency;—these, and numerous other interesting questions, must be left for future research and investigation.

The production of light by inflammation, is an object of great importance to society at large, as well as to the chemist. It appears to arise immediately from the strong ignition of a body, while rapidly decomposing. Most solid bodies in combustion are kept, partly from a want of the access of air, and partly from the vicinity of conducting bodies, at a low degree of ignition. But when vapours rapidly escape into the air, it may, and does frequently happen, that the combustion, instead of being carried on merely at the surface of the mass, penetrates to a considerable depth within, and from this, as well as from the imperfect conducting power of the surrounding air, a white heat, or very strong ignition is produced. The effect of lamps and candles depends upon these considerations. A combustible fluid, most commonly of the nature of fat oil, is put in a situation to be absorbed between the filaments of cotton, linen, fine wire, or asbestos. The extremity of this fibrous substance called the wick, is then considerably heated. The oil evaporates, and its vapour takes fire. In this situation the wick being enveloped with flame, is kept at such a temperature that the oil continually boils, is evaporated, burns, and by that means keeps up a constant flame. Much of the perfection of this experiment depends on the nature, quantities, and figure of the materials made use of. If the wick be too large, it will supply a greater quantity of the fluid than can be well decomposed. Its evaporation will therefore diminish the temperature, and consequently the light, and afford a fuliginous column, which will pass through the centre of the flame, and fly off in the form of smoke. The magnitude of the wick may, from time to time, in candles, be reduced, as to length, by snuffing; but this operation will not remedy the evils which arise from too great a diameter. If the oil be not sufficiently

ciently combustible, the ignition will be but moderate, and the flame yellow; and the same effect will be produced if the air be not sufficiently pure, or abundant. An experiment to this effect may be made by including the flame of a small candle or lamp in a glass tube about one inch in diameter, standing on the surface of a table. The air which passes between the glass and the table, will be sufficient to maintain a very bright flame; but if a metallic covering, perforated with a hole of about a quarter of an inch diameter, be laid upon the upper orifice of the tube, the combustion will be so far impeded, that the flame will be perceptibly yellower. The hole may then be more or less closed at pleasure by sliding a small piece of metal, for example a shilling, over it. The consequence will be, that the flame will become more and more yellow, will at length emit smoke, and if the hole be entirely closed, extinction will follow.

The smell arising from the volatile parts which pass off, not well consumed, from a lamp or candle, must be different according to the nature of those parts. This depends chiefly on the oil, but in some measure upon the wick. When a candle with a cotton wick is blown out, the smell is considerably more offensive than if the wick be of linen, or of rush; but less offensive than if the supply of the combustion had been oil. Whenever a candle or lamp is removed, the combustion is in some measure impeded by the stream of cold air against which it strikes. Smoke is accordingly emitted from its anterior side, and the peculiar smell is perceived. From this imperfection, lamps are much less adapted to be carried from place to place than candles.

From the necessity of the access of air there will be more light produced from a lamp with a number of small wicks, than with one large one, or from a number of small candles, than the same quantity of tallow used to make a single large one. In the lamp of Argand, the wick consists of a web of cloth in the form of a pipe or tube, the longitudinal fibres of which are thicker than the circular ones. This is passed by a suitable contrivance into a cylindrical cavity, which contains the oil, and there are other precautions in the construction of the apparatus by which the oil is regularly supplied, the access of air is duly permitted, as well within as without the circle formed by the upper edge of this cylindrical wick, and this edge can be raised or lowered at pleasure. Hence the possessor has it in his power to regulate the surface of the wick, so that the greatest flame consistent with perfect combustion may be produced; and the steadiness of the flame is secured by a glass shade or tube, which surrounds it, and in a certain degree accelerates the current of air.

In the illumination by candles, where the fused matter is contained in a cup or cavity of the matter not yet fused, it is of some consequence whether the substance be fusible at a high or low temperature. The difference between wax and tallow candles arises from this property. Wax being less fusible will admit of a thinner wick, and needs no snuffing; but in a tallow candle, it is absolutely necessary to have a large wick capable of taking up the tallow as it melts.

The difference of effect in illumination between a thick and a thin wick, cannot be better shewn than by remarking the appearances produced by both. When a candle with a thick wick is first lighted, and the wick snuffed short, the flame is perfect and luminous, unless its diameter be very great; in which last case, there is an opaque part in the middle where the combustion is impeded for want of air. As the wick becomes longer, the space between its upper extremity and the apex of the flame is diminished; and consequently the oil which issues from that extremity, having a less space of ignition to pass through, is less completely burned,

burned, and passes off partly in smoke. This evil continues to increase, until at length the upper extremity of the wick projects beyond the flame, and forms a support for an accumulation of soot, which is afforded by the imperfect combustion. A candle in this situation, affords scarcely one tenth of the light which the due combustion of its materials would produce; and tallow candles, on this account, require continual snuffing. But on the contrary, if we consider the wax candle, we find, that as its wick lengthens, the light indeed becomes less, and the cup becomes filled with melted wax. The wick however, being thin and flexible, does not long occupy its place in the centre of the flame; neither does it, when there, enlarge the diameter of the flame, so as to prevent the access of air to its internal part. When its length is too great for the vertical position, it bends on one side; and its extremity, coming into contact with the air, is burned to ashes, excepting such a portion as is defended by the continual afflux of melted wax, which is volatilized and completely burned by the surrounding flame. We see therefore, that the difficult fusibility of wax renders it practicable to burn a large quantity of fluid by means of a small wick; and that this small wick, by turning on one side in consequence of its flexibility, performs the operation of snuffing upon itself, in a much more accurate manner than it can ever be performed mechanically.

LIME. Is made by exposing chalk or other native combinations of calcareous earth and fixed air, to ignition, in a furnace properly adapted for that purpose, called a lime-kiln. The heat must be of considerable intensity, and continued twelve or fifteen hours. A less time will be sufficient if the heat be greater, or a longer if it be more moderate. The effect of this process is to drive off the fixed air and water, which compose about half the weight of such stones. Calcareous earth thus treated, is said to be in a caustic state, from its disposition to combine with and destroy the organization of animal substances, by forming a soap with their fat parts. As calcareous earth is infusible by the heat of a furnace, there would be no danger from too violent a heat if the specimens of chalk or lime-stone were pure; but as this is seldom the case, an extreme degree of heat produces a commencement of vitrification in the compound stone, and enables it to preserve its solidity when attempted to be made into mortar. This is called over burned lime.

If the calcination be perfectly accomplished, the quick lime will have a very strong tendency to combine with water. When this fluid is thrown upon a mass of quick lime, it becomes hot, cracks and splits with noise, emits boiling hot vapour, falls to pieces, and is in a very little time totally reduced to a fine powder. This experiment is even attended with light, if performed in the dark. Quick lime exposed to the air attracts, in the course of time, a sufficient quantity of water to pulverize it. It is then called lime slaked in the air. It resumes very little fixed air by this exposure.

The paste of lime mixed with sand to give it firmness, is well known for its utility in the art of building. It is disposed to resume its original state and become stone again, by a long course of drying and re-absorption of fixed air. The drying may be greatly accelerated by adding one quarter of the weight of mortar, of quick lime in powder, a very short time before the mixture is used. This effect is similar to what takes place in the use of the natural compound called plaster of Paris, which consists of gypsum, and a small portion of uncombined lime. See EARTH CALCAREOUS.

LINEN FOSSIL. The fibrous amianthus. Its fibres being long, parallel, and

and in a certain degree flexible, afford the facility of making it into cloth, which is incombustible in the moderate heat of a fire; but may be fused, if the temperature be considerably raised. See ASBESTOS.

LINSEED. See OIL.

LIQUEFACTION. A chemical term not much used. In some instances it is synonymous with the word fusion, in others, with the word deliquescence, and in others again, with the word solution. It may easily be imagined, therefore, that accurate writers will use those terms respectively, because more definite.

LIQUID AMBER. A resinous juice which flows from a large tree (*Liquidambar styraciflua* Lin.) growing in Virginia, Mexico, and other provinces in America. This juice is at first about the consistence of turpentine, but by long keeping hardens into a resin: it is of a yellow colour inclining to red, of a warm taste, and a fragrant smell, not unlike that of storax heightened with a little ambergris. It was formerly of great use as a perfume, but is at present a stranger to the shops.

LIQUOR OF FLINTS. The preparation of this liquor consists in uniting, by fusion, powdered flints or sand with a sufficient quantity of fixed alkali, so that a compound results from it, in which the properties of the alkali prevail, and particularly a total solubility in water. For this purpose, one part of ground flints or sand is to be well mixed with three or four parts of fixed alkali. The mixture is to be put into a crucible, which ought to be very large, in proportion to the quantity of matter. The crucible is then to be placed in a forge or good melting furnace, and gradually heated.

When this mixture has acquired a certain heat, a considerable boiling and swelling are observable, occasioned by the action of these two matters upon each other. To prevent the matter in this state from flowing over the crucible, this ought to be large, and the fire gradually raised. A part only of the mixture may be put into the crucible at once; and when its effervescence is over, the rest may be added at different times, taking care that each portion to be added be previously heated, to prevent explosion from any moisture which it might contain, when mixed with red-hot melted matter.

When the effervescence of all the mixture is over, it is to be kept in a good fusion during a quarter of an hour, and is then to be poured upon a greased stone or plate of iron. The matter when cold is brittle, and seems vitrified. It is even transparent like glass, when the quantity of alkali is only double or nearly double the quantity of flints. It quickly and strongly attracts moisture from the air, and is entirely soluble in water, except a very small portion of earthy matter. But a similar earth is also separated from pure considerably fixed alkali, during its solution in water.

The filtrated solution is at first clear, and limpid; but it afterwards becomes turbid, and forms an earthy sediment, like that formed by solutions of fixed alkali, only the former seems more copious. This liquor has all the properties of liquid fixed alkali.

All these properties of alkaline salts, and particularly its total solubility in water, are caused by the quantity of fixed alkali which enters into this kind of vitrified matter. As compound bodies partake always of the properties of their component principles, and as the properties of the principle which predominates in the composition of any body, do also predominate in that body, we may perceive why the properties of the fixed alkali in the present combination should be

more sensible than those of the earthy matter, or flints. The alkali communicates to the earthy matter some of its strong disposition to unite with water. The flints are really kept dissolved in water, and by this experiment they are consequently reduced into a liquor, and hence it has been called the liquor of flints. If any acid be added to the liquor of flints, so as to saturate the alkali, the flint which was kept dissolved in water by means of this alkali, will be now precipitated in the state of a fine earth. Macquer mentions a singular fact from Pott, that the earthy precipitate will be entirely taken up, if a redundancy of acid be added; but this is contrary to the results of experiment by Bergman, Klaproth, and other eminent chemists; though an enquiry into the cause, which seems to have misled Pott, Baumé, and others, certainly deserves to be investigated.

The glasses which contain too much alkaline salt in their composition, or which have not sustained a fire long or strong enough to unite the earth intimately with the fixed alkali, are partly soluble in acids, have sometimes even an alkaline taste, tarnish, and moisten in the air.

LIQUOR OF LIBAVIUS. See **TIN**.

LIQUORICE. The saccharine extract from liquorice is prepared by strong decoction in water. It is prepared in the large way in Spain and some parts of Germany. The black colour arises from coal produced by the empyreuma towards the end of the process. Neumann found that one ounce of the Spanish extract water dissolved seven drachms two scruples, leaving a residue from which spirit extracted nothing. Rectified spirit first applied, dissolved four drachms two scruples out of an ounce, which consisted of nearly the whole of the sugar; for though water took up three drachms of the remainder, it was nearly tasteless.

LITHANTHRAX. Pit coal, or stone coal: a black, solid, compact, brittle, inflammable substance, of a moderate hardness, laminated texture, more or less shining, but in few specimens capable of a good polish. None of the pit coals are fusible, though some exhibit an imperfect degree of fusibility. All the specimens leave an earthy residue, when burned. It appears to consist of asphaltos, intimately mixed with a small proportion of earth, mostly of the argillaceous kind, seldom calcareous, and frequently intermixed with pyrites, either in nodules, or diffused in such small particles as scarcely to be discerned. According to Gerhard, quoted by Kirwan, ardent spirit extracts a red colour from it; caustic fixed alkali attacks the bituminous part, and far oils act on and form a varnish, at least with some sorts of it: a fixed alkali has never been found in it, nor any sulphur, except it contained pyrites. See **COAL**.

LITHARGE. A calx of lead in an imperfect state of vitrification. When silver is refined by cupellation with lead, this latter metal, which is scorified, and causes the scorification of the imperfect metals alloyed with the silver, is transformed into a matter composed of small semi-transparent shining plates, resembling mica; which is litharge. Litharge is more or less white or red, according to the metals with which the silver was alloyed. The white is called litharge of silver, and the red has been improperly called litharge of gold.

Litharge may be easily revived into lead; accordingly much of that which is produced by refining in the large way is reduced, by being melted upon burning coals. The part of it which is least altered by mixture with other metals is thus reduced, and by this method good and saleable lead is obtained. The rest of the litharge of these refineries is sold and used for various purposes. Potters use much of it for glazing their ware. It is employed for the preparation of some plasters,

plasters, and other external remedies; and also in painting, to render linseed oil drying. Lastly, it is added in the composition of some glasses, for it is very fusible, and assists the fusion of other substances. It has in general the same properties as the other calces of lead. All the litharge which is commonly sold comes from refineries. The quantity formed there is more than sufficient for the demand. See LEAD.

LITHOLOGY. The systematical arrangement of stones.

LITHOMARGA. See EARTH, FULLERS.

LITMUS. See HELIOTROPIMUM.

LIVER OF ANTIMONY. A combination produced by detonating equal parts of crude antimony and nitre in a large crucible, and afterwards fusing the mass. The matter when cold is found to consist of two distinct substances, separable by the blow of a hammer. The upper matter is a saline scoria, composed of liver of sulphur, vitriolated tartar, and a portion of antimony. The lower matter, or liver of antimony, is heavy, opaque, compact, red, and brittle. Its component parts appear to be, the calx of antimony with sulphur, and probably some of the alkali. There is reason to think that the calcination of the metal, the dissipation of the sulphur, and other circumstances, may vary according to the management of the heat. But this scarcely deserves to be enquired into, because the compound is little used in medicine, and enters into none of the operations in philosophical chemistry.

LIVER OF ARSENIC. See ARSENIC.

LIVER OF SULPHUR. The general name of sulphureous hear, or liver of sulphur, has been given to a compound formed of sulphur, with some alkaline substance. This compound considered in general is of a brown colour, resembling that of the liver of animals; decomposable by vital air; soluble in water, in which state of solution it emits a fetid smell; precipitable in part by acids, which disengage a peculiar elastic air, called HEPATIC AIR, which see. There are six kinds of liver of sulphur produced by ponderous earth, magnesia, lime, and the three alkalis. The properties of each require to be particularly examined.

Pure ponderous earth does not appear to act strongly on sulphur; when these are boiled together with water, the liquid becomes in a small degree hepatic; but it combines much more intimately in the dry way. When a mixture of eight parts of ponderous spar in powder with one part of charcoal, is strongly heated in a crucible, a coherent mass is obtained without fusion, which readily dissolves in hot water, and has the smell and every other character of a hear. The solution is of a golden or orange colour. Fourcroy observed, that it crystallizes by cooling; it is then of a yellowish white. Exposure to air decomposes it, when it attracts moisture, and becomes of deeper colour; sulphur being precipitated, and ponderous spar regenerated. This liver of sulphur gives out hepatic air on the addition of any acid. When the barytic hear is precipitated by vitriolic acid, sulphur, and ponderous spar fall down; if nitrous or marine acid be used, the barytic nitre or muriate remains in solution, and the sulphur is deposited alone.

Sulphur combines with pure magnesia, by the assistance of heat. Mild magnesia is commonly used for this purpose, because more diffusible in water. A pinch of magnesia, with a like mass of the flowers of sulphur, is put into a bottle with distilled water; this vessel being perfectly filled, and well stopped, is exposed to the heat of a water-bath for several hours. The water being then filtered, has a fetid smell of rotten eggs; strongly colours metallic solutions, and

affords small crystalline needles by spontaneous evaporation: in a word, it is a true magnesian liver of sulphur; the magnesia being precipitable by fixed alkali, which has a stronger affinity with the sulphur. As to the latter combustible substance, its presence is easily ascertained by the addition of an acid, which separates it under the form of a white powder. Such was the kind of liver of sulphur which M. Le Roi, physician at Montpellier, dissolved in pure water, to imitate the hepatic mineral waters; but it is now known, that most of those waters do not contain a true hepar, but are mineralized simply by impregnation with hepatic air.

Lime unites much more readily with sulphur than the two substances before mentioned. If water be poured by a little at a time on a mixture of quick lime and flowers of sulphur, the heat produced by the action of the water on the lime is sufficient to promote the combination between it and the sulphur. If more water be added, it becomes reddish, and emits a fetid or hepatic odour, being in fact a solution of sulphur combined with lime. This hepar is not well prepared, but by the humid way, and it is often necessary to assist the combination by the application of a gentle heat, when the lime is not fresh. The compound is of a red colour; and the more caustic the lime, the deeper the red. When it is highly saturated, it deposits, by cooling, a layer of small needled crystals of an orange yellow, disposed in tufts, which appeared to Fourcroy to consist of flattened tetrahedral prisms, terminated by dihedral summits. These crystals gradually lose their colour by exposure to air, and become white and opaque, without any alteration in their form. Calcareous liver of sulphur, moistened with a small quantity of water, and distilled in the pneumatic apparatus, is partly decomposed, and affords a large quantity of hepatic air: if it be evaporated to dryness, and calcined in an open crucible till it emits no more fumes, the residue consists of selenite formed by the lime, and the vitriolic acid produced by the slow combustion of the sulphur. Calcareous liver of sulphur is quickly changed by exposure to air, losing its smell and colour, in proportion as the hepatic air is dissipated. When dissolved in a large quantity of water, the same alteration takes place, especially when it is agitated, as Mr. Monnet observes, in his Treatise on Mineral Waters. Selenite remains after those changes. When preserved in bottles not quite full, it deposits a black incrustation on the glass, pellicles being at the same time formed, which fall to the bottom of the liquor. If the vessel which contains it be well closed, it may be kept a long time unchanged. Calcareous liver of sulphur is decomposed by pure fixed alkalis, which have a stronger affinity than lime to the sulphur. Acids precipitate the sulphur in the form of a very subtle white powder, which has been called magistery of sulphur. Fixed air effects this separation as well as the others; but the action of neutral salts on calcareous liver of sulphur is not known.

The two pure or caustic fixed alkalis have a very strong action on sulphur; they form the true hepars, which are less decomposable, and more permanent, than the others. The dry fixed caustic alkalis act on sulphur when in the cold. With this intention, pure fixed alkali and sulphur in powder must be triturated in a mortar; the moisture of the air attracted by the alkali favours the re-action of the salt on the sulphur. The mixture becomes soft, assumes a yellow colour, emits a fetid smell, and is converted into hepar; but when this hepar is dissolved in water, the solution is of a pale yellow colour, and is found to contain a less quantity of sulphur than the same hepar prepared by heat. The alkaline hepar is prepared in laboratories in two methods, by the dry, or by the moist way;

way; the first process is performed by melting equal parts of dry lapis causticus and flowers of sulphur in a crucible: as soon as the mixture is entirely melted, it is to be poured out on a marble slab, and appears when cool to be of a red brown colour, resembling that of the liver of animals.

The two pure and caustic fixed alkalis act absolutely in the same manner on liver of sulphur, and are equally capable of dissolving it by the dry way. These combinations of caustic alkalis with sulphur have hitherto been little attended to; liver of sulphur having almost always been made with fixed alkalis, saturated with the fixed air. Yet Fourcroy observed two remarkable differences between these two kinds of hepar; those made with the mild fixed alkalis require a longer time for their preparation, because these salts are much less active. But the most important difference between the livers of sulphur made with caustic or dry alkalis, in the dry way, is the comparative state of their saturation. In fact, the first are brown, and more fetid when dissolved, and the fixed air they afford is much more hepatic and inflammable than that of the second. These last are of a paler colour, often of a greenish grey; their smell is weaker, and their composition less durable. The mild fixed alkalis appear to preserve their acid in their union with sulphur, the air from these hepars not being inflammable till it has been deprived of its fixed air by washing it in lime-water. The cause of the differences between livers of sulphur made with caustic alkalis, and with those made with mild alkalis, consists therefore in the presence of the acid in the latter, which diminishes the effect of the alkali.

Solid alkaline liver of sulphur, made with either of the fixed alkalis, is very fusible, and, like calcareous liver of sulphur, is decomposed by heating in close vessels, after having been moistened with a small quantity of water, in which circumstance it gives out much hepatic air. It is capable of assuming a crystalline form when it becomes solid by fusion; but this form has not yet been well described. While hot and dry it has a brown colour; in proportion as it cools and attracts the humidity of the air, it loses its colour, and becomes paler. The contact of the air soon gives it a greenish yellow colour; after which it is rendered liquid by the moisture it attracts, and is slowly decomposed, so as to become converted at the end of a certain time into vitriolated tartar, or Glauber's salt. It dissolves readily in water, immediately assuming a peculiar fetid smell; the hepatic air being formed by the re-action of the water: this solution is of a deep red colour; if the liver of sulphur has been recently prepared, but otherwise a green. The livers of sulphur prepared in the humid way, by heating a solution of either of the caustic fixed alkalis in water, with half their weight of powdered sulphur, exhibit the same properties as the solution here mentioned. They may therefore be described both under the common name of alkaline liquid hepar.

The liquid alkaline liver of sulphur, when very strong, deposits irregular needle-formed crystals by cooling. It is decomposable by the action of heat. When distilled in the pneumatophyl apparatus, it affords hepatic air: exposure to air likewise decomposes it, so that it becomes turbid; pellicles are then formed, and sulphur deposited. Bergman and Scheele thought that this decomposition is produced by the vital air of the atmosphere; a small quantity of liquid liver of sulphur being placed under a glass vessel with vital air, the latter is entirely absorbed, and the hepar decomposed. Mr. Scheele has even proposed the application of this fact to eudiometrical purposes; and it is in fact one of the best methods of ascertaining the purity of the air.

Earths and earthy salts have no action on alkaline liquid hepar when very pure; but if it has been prepared with a mild alkali, it becomes turbid by the addition of lime-water. Acids decompose it, by uniting with the alkali, and precipitating the sulphur in the form of a very fine white powder, called magistery of sulphur. Spirit of nitre poured on solid liver of sulphur in fusion, produces a detonation. All the acids decompose alkaline liver of sulphur, and disengage hepatic air. See AIR HEPATIC.

LIVER STONE. See LAPIS HEPATICUS.

LIXIVIAL. Those salts are called lixivial which have been extracted by lixiviation, and these chiefly are fixed alkalis; which are therefore called lixivial salts. See ALKALI.

LIXIVIATION. The application of water to the fixed residues of bodies, or the purpose of extracting the saline part.

LIXIVIUM. A solution of residual salts, obtained by lixiviation.

LOADSTONE. An iron ore whose constitution has not yet been properly examined. It is of a dark or black lead colour, generally of considerable hardness, weight, and closeness of texture. It is supposed to contain much iron in the metallic state, or nearly so. It attracts iron or steel filings, by which criterion it is easily known.

LOAM. A natural mixture of clay and sand. The coloured clays and loams participate of iron; hence many of these melt in a strong fire, without any addition; both clay itself, and mixtures of it with crystalline earths, being brought into fusion by ferrugineous calces, though the fusible mixtures of clay and calcareous earths are by the same ingredient prevented from melting. The bricks made from some loams, particularly the Windfor, are, when moderately burnt, remarkably free, so as to be easily rubbed smooth, cut, sawed, grooved, &c. Hence their use in building furnaces, &c. They bear a considerably strong fire, but have been frequently melted in a vehement one.

LODESTONE. A name given by the Cornish miners to stones likewise called tin-stone. They consist chiefly of stones or sand of different kinds, through which calx of tin is invisibly disseminated. They are heavy and of various colours, but blue, grey, black and brown are the commonest.

LOGWOOD. India, Jamaica*, or Campeachy wood has received those names from the places where it grows most plentifully. It is very common at Jamaica, and on the eastern shore of the bay of Campeachy; and is found also at St. Croix, Martinico, and Granada.

The tree is called by Linnæus *hæmatoxylum campechianum*. It grows very high and large in a good soil: the bark is thin, smooth, and of a bright grey, or sometimes yellowish: the trunk is straight and prickly: the leaves somewhat resemble those of the bay tree in appearance, and also in their aromatic qualities, whence the tree has been called aromatic bay, or Indian bay: its seeds have been improperly called clove seeds, from their flavour, and in England are known by the name of Jamaica pepper, or all-spice.

Logwood is so heavy as to sink in water, hard, compact, of a fine grain, capable of being polished, and scarcely susceptible of decay. Its predominant colour is red, tinged with orange, yellow, and black.

* In England, the name of Jamaica wood is commonly applied to the better species of mahogany, the inferior kind being brought from Honduras. Hamilton.

For use, its juice as it is commonly called may be extracted by decoction with water. It yields its colour both to spirituous and watery menstrua. Alcohol extracts it more readily and copiously than water. The colour of its dyes is a fine red, inclining a little to violet or purple, which is principally observable in its watery decoction. This, left to itself, becomes in time yellowish, and at length black. Acids turn it yellow: alkalis deepen its colour, and give it a purple or violet hue. Vitriolic, nitrous, and muriatic acids produce in it a small quantity of a precipitate, which is some time in separating, and its colour, with the vitriolic acid, is a dark red; with the nitrous, feuillemort; with the muriatic, a lighter red. The supernatant liquor is transparent, of a deep red colour with the vitriolic and muriatic acids, and yellowish with the nitrous. The acid of sugar forms a light marone precipitate; the liquor remaining transparent, and of a yellowish red. The acetous acid acts nearly in the same manner, except that the colour of the precipitate is a little deeper. Tartar gives the same precipitate as vinegar, but the liquor remains turbid, and more inclined to yellow. Fixed alkali occasions no precipitate, but changes the decoction to a deep violet, which afterwards becomes nearly brown. Alum produces a pretty copious precipitate, of a lightish violet colour; the liquor remaining violet, and nearly transparent. Alum and tartar occasion a dark red precipitate in tolerable quantity; the liquor remaining transparent, and of a yellowish red. Vitriol of iron gives it instantly a blueish black colour, like that of ink; a pretty copious precipitate of the same colour is produced, and the liquor remains turbid a long while; but if it be sufficiently diluted, and especially if there be a small excess of the vitriol, all the black matter is at length deposited. Vitriol of copper produces a very copious precipitate, of a browner and less bright black than the preceding: the liquor remains transparent, and of a very deep brownish or yellowish red. Sugar of lead instantly occasions a black precipitate, with a slight reddish tinge; the liquor remaining transparent, and of the colour of very pale beer. Lastly, tin dissolved in aqua regia forms immediately a precipitate of a very fine violet or purple, almost prune de Monsieur: the supernatant liquor is very clear, and perfectly colourless.

Stuffs would take only a slight and fading colour from decoction of logwood, if they were not previously prepared with alum and tartar. A little alum is added also to the bath. By these means they acquire a pretty good violet.

A blue colour may be obtained from logwood, by mixing verdegris with the bath, and dipping the cloth till it has acquired the proper shade.

The great consumption of logwood is for blacks, to which it gives a lustre and velvety cast, and for greys of certain shades. It is also of very extensive use for different compound colours, which it would be difficult to obtain of equal beauty and variety, by means of drugs affording a more permanent dye.

Juice of logwood is frequently mixed with that of brasil, to render colours deeper; their proportion being varied according to the shade desired.

Logwood is used for dyeing silk violet. For this the silk must be scoured, alumed, and washed; because without aluming it would take only a reddish tinge, that would not stand wetting. To dye silk thus, it must be turned in a cold decoction of logwood, till it has acquired the proper colour: if the decoction were used hot, the colour would be in stripes and uneven.

Bergman has already observed, that a fine violet might be produced from logwood, by impregnating the silk with solution of tin. In fact, we may thus obtain, particularly by mixing logwood and brasil in various proportions,

a great number of fine shades, more or less inclined to red, from lilac to violet.

If decoction of logwood be substituted for that of brasil in the process communicated by Mr. Brown, a fine violet colour will be obtained; and if the two be mixed, we shall have shades of puce colour, and prune de Monsieur, more or less inclining to red. See BRAZIL WOOD.

The remarks made on brasil are also applicable to logwood, the colouring matter of which exhibits similar properties. Berthollet.

LUDUS HELMONTII. An indurated marle, composed of various pieces of a whitish brown colour, separated into a great number of polygonous compartments, the boundaries of which are formed of matter of a lighter colour than the rest. According to Bomare, the ludus stellatus Helmontii, found in the county of Kent, is covered with a kind of striated selenite, resembling the zeolite.

It is for the most part of a globose figure, seldom flat, but often convex on the outside. And sometimes with a concave surface.

According to Wallerius, the ludus Helmontii loses by calcination about half of its weight; and, on being urged by fire, is melted into a black glossy slag. It effervesces strongly with aqua fortis, and this solution is of a yellow colour. But what seems very extraordinary, by adding to it some oil of tartar per deliquium, bubbles are emitted, from which a great number of slender black threads, or filaments, are produced, sticking like a cobweb to the sides and bottom of the vessel.

This stone is found quite separate by itself, as well as various stalagmites, and crustaceous bodies, on the strata of argillaceous earth, in various parts of Europe, chiefly in Lorraine, Italy, England (in the counties of Middlesex and Kent), and elsewhere.

LUMACHELLA. A conglutinated, calcareous stone, composed of shells and coral, united together by a cement of the same nature. When they have many colours, they are called marbles, and employed as such. In the island of Gotland there is found one of this kind of one colour only, which on that account is not called marble, or used as such.

LUNA. The alchymist's term for silver.

LUNA CORNEA. The combination of marine acid and silver. See SILVER.

LUNAR CAUSTIC. The nitre of silver, fused in a low heat. See SILVER.

LUTE. In many chemical operations, the vessels must be covered with something to preserve them from the violence of the fire, from being broken or melted, and also to close exactly their joinings to each other, to retain the substances which they contain, when they are volatile and reduced to vapour. For this purpose several matters are employed, called in general lutes.

The lutes with which glass and earthen ware retorts are covered, ought to be composed of nearly equal parts of coarse sand and refractory clay. These matters are to be well mixed with water and a little hair, so as to form a liquid paste, with which vessels are to be covered, layer upon layer, till it is of the required thickness. See COATING.

The sand mixed with the clay is necessary in this lute, to prevent the cracks which are occasioned by the contracting of clay during its drying, which it always does when it is pure. The hair serves also to bind the parts of the lute, and to keep

keep it applied to the vessel: for, notwithstanding the sand which is introduced into it, some cracks are always formed, which would occasion pieces of it to fall off.

The lutes with which the joinings of vessels are closed, are of different kinds, according to the nature of the operations to be made, and of the substances to be distilled in these vessels.

When vapours of watery liquors, and such as are not corrosive, are to be contained, it is sufficient to surround the joining of the receiver to the nose of the alembic, or of the retort, with slips of paper or of linen, covered with flour-paste. In such cases also slips of wet bladder are very conveniently used.

When more penetrating and dissolving vapours are to be contained, a lute is to be employed of quick-lime flaked in the air, and beaten into a liquid paste with whites of eggs. This paste is to be spread upon linen slips, which are to be applied exactly to the joining of the vessels. This lute is very convenient, easily dries, becomes solid, and sufficiently firm.

Lastly, when saline, acid, and corrosive vapours are to be contained, we must then have recourse to the lute called fat lute. This lute is made by forming into a paste some dried clay finely powdered, sifted through a silken searce, and moistened with water, and then by beating this paste well in a mortar with boiled linseed oil, that is, oil which has been rendered drying by litharge dissolved in it, and fit for the use of painters. This lute easily takes and retains the form given to it. It is generally rolled into cylinders of a convenient size. These are to be applied, by flattening them, to the joinings of the vessels, which ought to be perfectly dry, because the least moisture would prevent the lute from adhering. When the joinings are well closed with this fat lute, the whole is to be covered with slips of linen spread with lute of lime and whites of eggs. These slips are to be fastened with pack-thread. The second lute is necessary to keep on the fat lute, because this latter remains soft, and does not become solid enough to stick on alone.

LYCOPODIUM. The fine dust of lycopodium, or puff-ball, is called by some, on account of its great inflammability, vegetable sulphur. The puff-ball is the seed-vessel of a species of moss named by Tournefort *Muscus squamosus vulgaris repens clavatus*; and the dust is properly the seeds of the plant. There are sundry other vegetables, as polypodies, ferns, corniferous trees, &c. whose seeds are like a yellow, impalpable farina, so subtle as to be blown away by the least motion of air: it is this dust which has given rise to some reports of showers of brimstone.

The dust of lycopodium, diffused or strewed in the air, takes fire from a candle, and burns off like a flash of lightning, with a considerable noise. It is used in the London theatres. A quantity laid together upon burning coals does not flame, but smokes away with a fetid smell: burned in a red-hot crucible, it leaves a very small proportion of a light cobweb-like matter. It does not, as some report, take fire from flint and steel, nor explode like gunpowder; nor does it seem to detonate more violently with nitre than other inflammable matters do. Olearius relates, that the Russians employ much of it in fire-works, but does not inform us in what manner.

There is a curious experiment of taking a shilling from the bottom of a vessel of water without wetting the hand. It is said to be done by strewing a small quantity of the dust of lycopodium on the surface of the water, which it so

strongly repels, as to form a covering for the hand, and defend it from the contact of the water.

Neumann examined this substance. It appears to contain a resinous matter, and an oily one of the expressible kind, intimately combined together, so as to be both extracted, at least in part, by rectified spirit of wine: on inspissating the tincture, the oil separated, remained permanently fluid, and would not unite again even with the resinous extract: it is remarkable that pure spirit would no longer touch this resin any more than the oil. The quantity thus extracted from an ounce of the powder amounted only to a dram: water did not take up near so much; it was with great difficulty he obtained by water eight grains of extract from an ounce. Both the water and spirit arose in distillation unchanged.

By destructive distillation in an open fire, he gained a large proportion of empyreumatic oil, no less than two ounces and a half from four: this was preceded, not by an acid liquor, which most vegetables yield on the same treatment, but by an alkaline one: the black coal remaining in the bottom of the distilling vessel weighed five drams.

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MACE, one of the exterior coverings of the nutmeg, is at first of a purplish red colour, which changes before it arrives among us to an orange yellow, and by long keeping grows paler and paler. Mace is a warm aromatic, like the nutmeg, accompanied with a degree of bitterness; and like that spice also contains both an essential and expressible oil.

From sixteen ounces of mace, Neumann obtained with rectified spirit four ounces and a half of extract, which retained some of the expressible, and the more ponderous part of the essential oil, the lighter arising towards the end of the inspissation, and impregnating the distilled spirit: from the residuum were obtained two ounces and a half of gummy extract, with five drams of essential oil, which arose during the inspissation, and sunk to the bottom of the distilled water: the residuum gave with rectified spirit three ounces of an oily extract, eight ounces and a half remaining undissolved. The watery extract has an unpleasant somewhat saline taste, which that of nutmegs has nothing of. On expression, mace yields an oil less consistent than that of nutmegs, and which is usually brought from the East Indies in glass or porcelain vessels.

MACERATION. The steeping of a body in a cold liquor. It does not differ from **DIGESTION**, excepting that the term is never used when the temperature of the mass is raised beyond that of the surrounding air. It is obvious that maceration, or digestion without heat, must be used in all requisite cases wherein the fugitive nature of some of the component parts of the subject of examination,

or its disposition to become changed by heat, renders the process of digestion, assisted by heat, unfavourable to the intended analysis.

MADDER. The following article is chiefly extracted from Berthollet's *Treatise on Dyeing*. Madder, a substance very extensively employed in dyeing, is the root of a plant which Linnaeus divides into two species; the first, *rubia tinctorum foliis fenis*; the second, *rubia peregrina foliis quaternis*. Of the first there are two varieties, the cultivated madder and the wild madder, called also *rubia sylvestris monspessulana major*.

Although madder will grow both in a stiff clayey soil, and in sand, it succeeds better in a moderately rich, soft, and somewhat sandy soil: it is cultivated in many of the provinces of France, in Alsace, Normandy, and Provence: the best of European growth is that which comes from Zealand.

There are various methods of cultivating and preparing madder, and many treatises have been written on the subject: that of M. Duhamel may be consulted, but more particularly that of M. Le Pileur d'Apligny, published at the end of his *Art of Dyeing Threads and Cotton Stuffs*.

The madder prepared for dyeing is distinguished into different sorts: that obtained from the principal roots is called grape madder (*garance grape*); the non grape is that which is produced from the stalks, which by being buried in the earth are transformed into roots, and are called layers (*couchis*): each of these kinds is sub-divided into *robée*, *mi-robée*, *non-robée*, *short*, or *mull*, (*mûle*).

When the madder roots are gathered, the layers are separated from them, to form the non grape; and such of the fibres of the roots as do not exceed a certain degree of thickness are added, as are also those roots which are too thick, and which contain a great deal of heart or ligneous part: the best roots are about the thickness of a goose quill, or at most of one's little finger; they are semi-transparent, and of a reddish colour; they have a strong smell, and the bark is smooth.

When the madder is gathered and picked, it must be dried, in order to render it fit for grinding and being preserved: in warm climates it is dried in the open air; in Holland, by means of stoves, which sometimes communicate too great a degree of heat, and change its colour by an admixture of fuliginous particles. Hellot ascribes the superiority of the madder which comes from the Levant, to the circumstance of its having been dried in the open air.

After the root has been dried, it must be shaken in a sack, or lightly beaten on a wooden hurdle, after which it must be sifted or winnowed. In this way the earth is separated from it, and the bilion is removed, a name by which the small roots and their bark are distinguished. After this, nothing remains but to reduce it to powder, which may be done by a vertical millstone, or by pestles, or even by a common fluff-mill.

All the parts of the madder cannot be powdered with equal facility; the outer bark and ligneous parts are more easily pounded than the parenchymatous parts. Advantage is taken of this circumstance in order to separate those parts, as they do not all give the same colour; the outer bark, as well as the wood within, affords a yellowish colour, which spoils the red we wish to obtain. This separation established the distinction of madder into *robée*, *mi-robée*, and *courte*. After the first operation of the mill, the madder is passed through a sieve, with a cover fitted to it, by which means, what is called the short madder, which is intended for tan and mordoré colours, is obtained; the remainder is again ground

and sifted, and thus the mi-robée is obtained; and a third operation affords the robée. The madder thus powdered is to be preserved in a dry place, well packed in casks, where from its natural unctuousity it concretes into lumps.

Mr. Beckmann* agrees with Mr. Hellot in opinion, that the heat of stoves injures the colour of madder, and that it would be better to dry it in the air only, the effect of which might be promoted by various means. He finds that common ovens, immediately after the bread is taken out, may be used instead of the Dutch stoves, when artificial heat is to be employed. M. D'Ambourney† has made some interesting experiments on madder; he thinks, that the fresh root may be used in dyeing, with as much advantage as the powdered. He observed that four pounds of the fresh are equal to one of the dried, although in the drying seven-eighths of its weight are lost; the expence of stoving, packing, and sifting is saved; and it is only necessary to take care that the roots be thoroughly washed in a current of water as soon as they are taken out of the ground; they are afterwards cut into pieces, and bruised by the vertical mill. In dyeing with the fresh roots, on account of the quantity of water they contain, we must take care not to put too much water into the bath. Mr. Beckmann subscribes to M. D'Ambourney's opinion, though he has constantly made one observation which seems to contradict it, that madder is more fit for dyeing, after having been preferred for two or three years, than when fresh.

In the neighbourhood of Smyrna, and in the island of Cyprus, a kind of madder is cultivated, which affords a more lively red than that raised in Europe; on which account, it is employed in the preparation of the Adrianople red. In the countries where it grows it is called chioeborza, and hazala, but it is commonly known by the name lizari. It is now cultivated in Provence, and Mr. Beckmann has raised it with great success at Gottingen.

The red colouring matter of madder may be dissolved in alcohol, and on evaporation, a residuum of a deep red is left. Fixed alkali forms in this solution a violet, the vitriolic acid a fawn-coloured, and the vitriolated tartar a fine red precipitate. Precipitates of various shades may be obtained by alum, nitre, chalk, sugar of lead, and the marine salt of tin.

When madder is macerated in several portions of cold water successively, the last receives only a fawn colour, which appears entirely different from the peculiar colouring particles of this substance, and resembles that which is extracted from woods and other roots: this fawn-coloured substance does not perhaps belong to the pulp, but is peculiar in the ligneous and cortical parts.

After Berthollet had by repeated boiling exhausted the madder of such colouring parts as are soluble in water, it still retained a deep colour, and alkali extracted from it much colouring substance: the residuum which still remained coloured was very inconsiderable; so that the pulp appears to be entirely composed of colouring matter, a large part of which is not soluble in simple water.

Aerated muriatic acid, employed in sufficient quantity to change an infusion of madder from a red to a yellow colour, produces a small quantity of a very pale yellow precipitate; and the supernatant liquor is transparent, retaining a greenish yellow colour, more or less deep according to the quantity and strength of the aerated muriatic acid.

The quantity of this liquor required to destroy the colour of a decoction of

* Nov. Comment. Societ. Reg. Gotting. tom. viii.

† Délibér. & Mem. de la Société d'Agriculture de la Généralité de Rouen.

madder, is double what is necessary to destroy that of a decoction of an equal weight of brasil wood ; which proves that the colouring particles of madder are much better calculated to resist the influence of the air, than those of brasil wood. They would be easily changed, however, if not rendered fixed, by mordants. On this subject, Berthollet relates some experiments made by the celebrated Mr. Watt upon the best Zealand madder, and communicated to him.

A. This madder is of a brownish orange colour, and of the consistence of a coarse powder, possessing a slight degree of cohesion ; it attracts moisture, in which case it loses its properties, so as to become unfit for the purposes of dyeing.

B. With water it affords an infusion of a brownish orange colour ; its colour cannot be extracted without a copious addition of water. Margraff directs three quarts of water for two ounces of madder. Its colouring particles may be extracted either by hot or cold water ; to the latter it appears to give a more beautiful colour ; its decoction is brownish.

C. When an infusion or decoction of this drug is slowly evaporated in an open vessel, a pellicle is formed on the surface, which gradually falls to the bottom ; after which fresh pellicles are successively formed until the evaporation is finished.

D. The extract thus prepared is of a dark brown ; it partly dissolves in water, to which it communicates a lightish brown colour.

E. The infusion set to digest for some days in an open vessel, which should be of such a height that the liquor reduced to the form of vapour may fall back again, deposits dark brown pellicles. The liquor remains of a brownish colour, and the pellicles are soluble in water, but with difficulty.

F. Alum forms in the infusion B a deep brownish red precipitate, composed of pellicles, and the supernatant liquor is of a yellow colour inclining to brown.

G. Mixed alkalis precipitate from this last liquor a lake of a blood red colour, which has greater or less intensity, according to the quantity of alum that has been dissolved in it. In this way, a blood red lake may be obtained ; but we cannot, by any means hitherto known, give it the brightness of cochineal lake : in oil it is transparent, but in water it is opaque and without beauty.

H. If a superabundant quantity of alkali be employed, the precipitate is redissolved, and the liquor becomes red.

I. The lake precipitated by vegetable alkali is of a more beautiful colour than that by the mineral alkali.

K. Calcareous earth precipitates a more dark and brown coloured lake than alkalis, particularly if it forms lime water.

L. If a few drops of alkali are added to the water employed in making the infusion B, the infusion extracts many colouring particles of a deep red bordering on brown. 1st. Alum precipitates a deep brown lake from this infusion. 2dly. Acids added in small quantity change it to a yellowish colour, and in greater quantity render it a brown yellow, but they precipitate nothing from it. 3dly. This infusion, evaporated to dryness forms a gummy extract, which easily dissolves in water.

M. If the infusion B be made with water very slightly acidulated with a mineral acid, it is yellowish. 1st. This liquor by long digestion becomes of a greenish brown, and the yellow appears to be destroyed. 2dly. The addition of an alkali restores the red colour, and the infusion then affords, on evaporation, an extract which readily dissolves in water.

N. If mild magnesia be added to the water used for the infusion B, the infusion is of a clear blood red, and on evaporation forms a blood red extract, which readily

readily dissolves in water. 1st. A solution of this extract, which is employed as a red ink, when exposed to the light of the sun becomes yellow. 2dly. Alum precipitates from this infusion a small quantity of an ill-coloured lake. 3dly. Alkalis give it a redder and more fixed colour.

O. If the infusion be made with a solution of alum, it is of an orange yellow. This infusion precipitated by an alkali, affords a lake resembling that of F, but its colour is not so good.

P. A solution of sugar of lead added to the infusion B, forms a brownish red precipitate. 1st. A solution of mercury in the nitrous acid, gives a purple brown precipitate. 2dly. A solution of vitriol of iron, a fine bright brown precipitate. 3dly. A solution of vitriol of zinc has not been tried. 4thly. A solution of vitriol of manganese, a purple brown precipitate. 5thly. A solution of iron in aqua-regia has not been tried.

Q. The infusion B being mixed while hot with the infusion of cochineal, a brownish red precipitate, bordering on a deep purple, was formed, of difficult solubility in water; by continuing the digestion, a greater quantity of this precipitate appeared. 1st. A pattern soaked in the preparation which the linen printers use, having been dyed in this mixture, took a brownish red colour; and after having been boiled in a solution of soap, the colour appeared pretty good. 2dly. The solution of soap became very red, but communicated a very indifferant colour to paper.

Wool would receive from madder, as has been already stated, only a perishable colour, if its colouring particles were not fixed by a base which occasions them to combine with the stuff more intimately, and which in some measure defends them from the destructive influence of the air. For this purpose, the woollen stuffs are first boiled for two or three hours with alum and tartar, after which they are left to drain; they are then slightly wrung and put into a linen bag, and carried into a cool place, where they are suffered to remain for some days.

The quantities of alum and tartar, as well as their proportions, vary much in different manufactories. Hellot recommends five ounces of alum and one ounce of tartar to each pound of wool; if the proportion of tartar be increased to a certain degree, instead of a red, a deep and durable cinnamon colour is produced, because, as we have seen, acids have a tendency to give a yellow tinge to the colouring particles of madder. Mr. Poerner somewhat diminishes the proportion of tartar, he directs that it should be only one seventh of the alum; Scheffer, on the contrary, directs that the quantity of tartar should be double that of the alum; but Berthollet found that, by employing one half tartar, the colour sensibly bordered more on the cinnamon than when the proportion was only one-fourth of the alum.

In dyeing with madder, the bath must not be permitted to boil, because that degree of heat would dissolve the fawn-coloured particles, which are less soluble than the red, and the colour would be different from that which we wish to obtain.

When the water is at a degree of heat which the hand can bear, Hellot directs us to throw in half a pound of the best grape madder for each pound of wool to be dyed, and to stir it well before the wool is put in, which must remain for an hour without boiling; but in order to be more certain of the dye, it may be boiled for four or five minutes towards the end of the operation. Mr. Beckmann advises the addition of a little alkali to the madder bath; Berthollet approves the plan in the dyeing of thread and cottons.

By

By this process reds are obtained, which are never so beautiful as those produced even by kermes, much less those from lake and cochineal; but as they cost but little, they are used for common low-priced stuffs. The madder reds are sometimes rose'd with archil and brasil wood, in order to render them more beautiful and more velvety; but the brightness given them in this way is not lasting.

The quantity of madder which Mr. Poerner employs, is only one third of the weight of the wool, and Scheffer advises only one fourth. Mr. Poerner says, that having added to the alum and tartar, a quantity of solution of tin of equal weight with the tartar, and, after two hours boiling, having let the cloth remain in the bath that had been left to cool for three or four days, he dyed it in the usual way, and obtained a pleasing red. He describes another process, in which, after having prepared the cloth by the common boiling, he dyed it in a bath but slightly heated with a larger quantity of madder, tartar, and solution of tin; he let the cloth remain twenty-four hours in the bath, and after it had become cold, he put it into another bath made with madder only, and there left it for twenty-four hours: in this way he obtained a pleasing red, somewhat clearer than the common red, and bordering a little on a yellow. According to Scheffer, by boiling wool with a solution of tin, the quantity of which he does not mention, with one fourth of alum, and by dyeing with one fourth of madder, an orange red is obtained.

Bergmann says, that if, without boiling the wool, it be dyed with one part of a solution of tin, and two parts of madder, it acquires a cherry colour, which when exposed to the air acquires a deeper tinge.

If wool be boiled for two hours with one fourth of vitriol of iron, then washed, and afterwards put into cold water with one fourth of madder, and then boiled for an hour, a coffee colour is produced. Bergmann adds, that if the wool has not been soaked, and if it be dyed with one part of vitriol of iron and two of madder, the brown obtained borders upon a red.

According to these chemists, by employing vitriol of copper as a mordant, we obtain from madder a clear brown bordering on yellow. A colour of the same kind will be produced, by dyeing the wool simply soaked in hot water, with one part of vitriol of copper and two of madder: if equal parts of these two substances be used, the yellow will be somewhat more obscure, bordering on a green; in both these cases, the colour does not become darker by exposure to the air.

Berthollet employed a solution of tin in various ways, both in the preparation and in the madding of cloth. He used different solutions of tin, and found that the tint was always more yellow or fawn-coloured, though sometimes brighter than that obtained by the common process.

Madder does not afford a colour sufficiently bright for dyeing silk; but De la Folie has given us a process for employing it for this purpose.

Half a pound of alum is to be dissolved in each quart of hot water, to which two ounces of pot-ash are to be added: after the effervescence has ceased, and the liquor has begun to grow clear, the silk must be soaked in it for two hours; it is then to be washed, and put into a madder bath. Silk dyed in this way becomes more beautiful by the soap proof *. Scheffer gives us a somewhat different process; the silk is to be alumed in a solution of four ounces of alum with six drams of chalk for each pound of scoured silk; when a sediment is formed, the solution

* Journal de Physique, tom. xiii. p. 66.

is to be decanted; and after having become quite cold, the silk is to be put into it, and to be left eighteen hours; it is then to be taken out and dried, after which it is to be dyed with an equal weight of madder, when it takes a pretty good, but rather dark red. Mr. Guliche also describes a process for dyeing silk with madder*; for one pound of silk he orders a bath of four ounces of alum, and one ounce of a solution of tin; the liquor is to be left to settle, when it is to be decanted, and the silk carefully soaked in it, and left for twelve hours; and after this preparation, it is to be immersed in a bath containing half a pound of madder softened by boiling with an infusion of galls in white wine; this bath is to be kept moderately hot for an hour, after which it is to be made to boil for two minutes. When taken from the bath, the silk is to be washed in a stream of water, and dried in the sun. Mr. Guliche compares the colour thus obtained, which is very permanent, to the Turkey red. If the galls are left out, the colour is clearer. A great degree of brightness may be communicated to the first of these, by afterwards passing it through a bath of brasil wood, to which one ounce of solution of tin has been added: the colour thus obtained, he says, is very beautiful and durable.

Madder is used for dyeing linen and cotton red, and even for giving them many other colours by means of different admixtures; it is the most useful of all the colouring substances employed in this kind of dyeing. It is proper to enter into a somewhat minute detail of the different means by which this kind of dye may be rendered more certain, more beautiful and varied. Thread does not so easily take a colour from madder as cotton, but the processes which succeed best for the one are likewise preferable for the other.

The madder red of cotton is distinguished into two kinds: one is called simple madder red; the other, which is much brighter, is called Turkey or Adrianople red, because it comes from the Levant, and has seldom been equalled in brightness or durability by our artists.

Madder reds likewise differ very much in brightness and permanency according to the processes employed. We are indebted to Mr. Vogler for some very interesting experiments on this subject. He first considers the mordants, and afterwards the preparation of the madder bath †.

The first mordant he tried, consisted of a solution of three drams of Roman alum in fourteen ounces of water. Thread and cottons boiled for some minutes in this solution, and afterwards passed through the different madder baths, which will be hereafter described, took a slight poppy-coloured red. Our author observed in this, and many other experiments, that Roman alum was much better than common alum, and gave greater brightness to the colours. He always used yellowish thread and cotton, which he first leyed, then washed and dried.

The above proportion of alum appeared to him the best; yet though he repeated the aluming three times, he was not able to give the thread and cotton a good colour. The addition of the smallest quantity of any kind of acid rendered it paler; the addition of arsenic produced no effect; sheep and cow-dung, and album grecum, added to the mordant, as also urine employed instead of water to dissolve the alum, contributed somewhat, but not much, to strengthen the colour. Common salt and sal-ammoniac had more effect, but these salts rendered the colour more dull; lime-water acted very much in the same way. The

* Vollständiges Farbe, &c. iv. band.

† Crell, Neueste Entdeckungen, vol. xiii. An. de Chym. t. iv.

substances which had the best effect were gum arabic, starch, fenugreek seed, and above all, glue. The author says he has attempted to impregnate thread and cotton with fish oil, hogs lard, and olive oil, but without success. The gastric juice and the ferous part of the blood of animals act like the glue.

The thread and cotton may be soaked alternately in a solution of glue and a solution of alum, or the glue may be dissolved with the alum, in the proportion of from one dram and a half to four drams, with the quantity of alum directed. It is necessary to choose fine glue. This substance used with alum produces a more saturated colour, but without alum the red is dusky.

The marine and nitrous salts of clay not only produce a more intense and durable red than alum, but the tint is pleasanter, more especially when the nitrous salt is employed. In general, marine salts render the colour darker, more saturated, and more durable. Corrosive sublimate produces the same effect.

Having dissolved in a strong ley of pot-ash, as much powdered white arsenic as it would take up with the assistance of heat, and mixed this solution, which had been diluted with two parts of water, with a saturated solution of alum, the mixture became turbid, and of the consistence of jelly; it recovered its transparency on adding gradually a solution of alum.

Thread and cotton soaked for twelve hours in this mordant, when washed and dried received from madder a beautiful well saturated colour. Thread and cotton, which had been for six hours in aqua regia, and afterwards washed and dried, took from madder a more beautiful and durable colour than that which dyes obtain from annotta; some bad madder, by means of this mordant, afforded a yellowish brown, of an agreeable shade.

This colour may be changed into a poppy-coloured red, which may be compared with the most beautiful colours of this hue, obtained from brasil wood and cochineal, by first soaking the stuff in a solution of alum and common salt, and boiling it a second time with madder.

Mr. Vogler macerated for a night three drams of pot-ash with an equal quantity of common madder in a pound of water; he then applied a boiling heat, and put into it some thread and some cotton, and after half a quarter of an hour's boiling, he took it out, rinsed and dried it, then soaked it in a solution of alum and common salt, after which he passed it through a solution of glue, and at last dipped it in a madder bath; it took a fine full red.

If to the preparation of madder and pot-ash annotta be added, the thread and cotton take in this bath a beautiful orange colour; it is thus that the dyers in many places prepare that colour, but it is not so durable as that above described.

If instead of pot-ash Roman alum be employed, a colour is obtained which is at first weak, though more lively than with the pot-ash, and on going on with the process a fine full red is obtained.

By giving a weak madder colour to thread and cotton that have been alumed, by afterwards soaking them in a solution of alum and salt, impregnating them with glue, and dyeing them a second time in a madder bath, they take a beautiful very lively red.

The red of thread and cotton coloured by two madderings was very much weakened by the nitrous, vitriolic, and muriatic acids, diluted with two parts of water, and became more or less pale and yellow. The action of the nitrous acid was the most powerful, and that of the muriatic the weakest; this last turned the colour brown. The vegetable acids have a much weaker action; a solution of

alum powerfully dissolved the colour, rendered it clearer, and at the same time brighter; pot-ash and lime-water have the property of extracting much of its colour, and changing it to a deep red.

Galls dispose thread and cotton to receive the madder colour. Mr. Vogler's preparation for galling consisted of five drams of black galls, kept for twenty-four hours in a pound of water, which was then boiled for ten minutes, and sometimes he added six drams of common salt. The galled thread and cotton, after having received the mordants of alum and salt, took with the madder a perfectly saturated colour, but which was of a dark red. Thread and cotton successively impregnated with a solution of tin and glue, steeped in an infusion of cochineal and galls, washed and dried, and afterwards impregnated with the alum and salt mordant, and last of all dyed in a madder bath, received an uncommonly beautiful colour, which was very bright and considerably durable. The mordant of alum and corrosive sublimate, and that of alum and salt, gave a somewhat deeper colour.

Mr. Vogler was equally successful, when instead of galls he used several other vegetable astringents, such as the ground bark of the alder and oak, the powdered bark of walnut-tree root, flowers and bark of pomegranate, the leaves, bark, and tops of the sumach. He made many experiments with metallic and earthy salts, all of which, except the aluminous and the solution of tin, appeared to him to be but little adapted, or entirely hurtful in the dyeing of red: the principal results were as follow:

The solution of nitre of lead employed as a mordant, produced a very loaded dirty-red inclining to brown. In general, solutions of lead used as mordants for thread and cotton, dispose them abundantly to receive colours from all vegetable colouring substances, but they have always a dark and dirty appearance. These mordants may be employed for brown or black colours; the bad brown just mentioned, for instance, will change to a perfect brown of a very beautiful shade, if passed through a mordant of alum and salt, and boiled a second time with madder. Mr. Vogler obtained a very fine black, by galling thread and cotton impregnated with salt of lead, and then putting them into a solution of vitriol of copper, and boiling them in a bath of logwood.

Cobalt dissolved in aqua regia produced a very pleasant colour nearly resembling a very saturated violet. A solution of vitriol of copper gave a bad lilac. Verdegris dissolved in vinegar produced the same effect.

The nitrous solution of copper produced a much more beautiful and saturated colour.

Thread and cotton that have received the mordant of vitriol of copper or iron, take in the madder bath a dirty dull violet colour.

Mr. Vogler having added the alkaline solution of arsenic above mentioned, to a moderately saturated solution of vitriol of copper or iron, produced a turbid mixture which effervesced, and he rendered it transparent by adding vitriol of iron. Thread and cotton impregnated with this preparation received a beautiful saturated puce colour, which penetrated them deeply.

The nitrous acid marine salts of iron produced a better effect than the vitriolic and acetous salts of the same metal. They afforded a beautiful well saturated violet colour. The alkaline solution of arsenic mixed with earthy and metallic salts, generally renders them better mordants for all colours. This likewise renders the effect of the mordants into which it enters more lasting, so that the stuff impregnated with it many years before, may be dyed without disadvantage; a circumstance

circumstance we do not remark respecting any other mordant, excepting a solution of tin. Vitriol of zinc afforded a weaker violet than vitriol of copper. Vitriol of lime and calcareous nitre produced no effect. Vitriol of manganese discovered some though but little action. Mr. Vogler remarks, that it is always necessary to rinse the cotton and thread when they come out of a mordant; if this precaution be neglected, a weak colour only is frequently obtained, where a strong one was expected, because the particles of the mordant dispersed through the bath, combine with the colouring particles and are precipitated with them; this precaution is especially necessary, when we dye with substances which do not contain much colouring matter.

Mr. Vogler prepares the madder bath in different ways. He put three drams of madder into from sixteen to eighteen ounces of water; he macerated it for twenty-four hours, then boiled it for a quarter of an hour, introduced the thread and cotton, and boiled them for half a quarter of an hour; he afterwards washed them in two or three waters, and then dried them in the shade: he remarks, that the colour of the stuff is taken away and destroyed by long boiling.

Fresh urine substituted for water affords more lasting colours; but in summer it is apt to become very soon putrid, so as to render the infusion incapable of giving the dye.

One dram of sheep's dung, or album grecum, produced the same effect as the urine.

Three drams of common salt, or one dram of sal ammoniac, produced a fuller but less bright colour. Vitriolated tartar and nitre had no effect.

Three drams of white sugar afforded a more beautiful and saturated colour; on the addition of four drams of long pepper, it was found to have become more capable of resisting the nitrous acid.

One dram or one and a half of starch or gum arabic thrown into the bath just as it begins to boil, and before the cotton is put in, gives a finer and more saturated colour; one dram of fenugreek seed produced very nearly the same effect.

If in the beginning of the digestion four drams of Spanish pepper are added, we obtain from the liquor colours that are more durable than the preceding, especially if we afterwards add three drams of common salt.

From one ounce to one ounce and a half of glue, in the state of jelly, thrown into the liquor as the ebullition commences, affords a particularly beautiful full colour; and the addition of three drams of common salt not only renders the colour more lasting, but preserves the infusion from becoming putrid.

The most beautiful colour of all, however, is obtained by mixing four drams of ox-gall with the decoction; but at the same time it must be observed, that this colour is more easily destroyed by the nitrous acid than any other.

All the madder baths, except those prepared with urine, glue, and animal dung, may be preserved for a long time without losing their power. Mr. Vogler kept some till they became mouldy and foetid, and yet they dyed very well; nay, he observes that they produced more durable colours, or, at least, colours which resisted the action of the nitrous acid more powerfully.

On putting from thirty-six to forty grains of crystals of tartar into the bath just as the linen was thrown in, the colour produced was found capable of resisting the nitrous acid. The vitriolic, nitrous, and muriatic acids, in very small quantity, produced the same effect; in too large a quantity, they weakened the colour and rendered it pale. One dram and a half of powdered alum made the colour

finer, but not more durable; twenty-four drams of corrosive sublimate rendered it more obscure, but more permanent. White arsenic employed in different proportions never occasioned the least change, though dyers frequently use it as well as orpiment, with a view of making the colour more durable.

In Mr. Vogler's experiments, cotton always took the colour better than thread; the difference however was not very great, when he employed linen or hempen cloth that had been a little worn, and that had become soft to the touch, and when its texture was loose and the thread slightly twisted.

M. Le Pileur d'Apligny gives a very minute description of the process employed at Rouen for dying cotton red; it is as follows:

The cotton must be scoured, galled with one part of galls to four of the cotton, after which it must be alumed with four ounces of Roman alum to one pound of cotton, and an equal weight of water; to the solution of alum, one twentieth part of a solution of soda, consisting of half a pound of soda to a quart of water, must be added.

Some use only half the quantity of soda, and one sixth less of water, which they replace by a solution of tartar and arsenic. M. Le Pileur d'Apligny thinks these last ingredients counteract each other. We have seen by Mr. Vogler's experiments, that tartar used with the mordant weakens the colour, and that arsenic was only useful when combined with an alkali.

Others add sugar of lead, or the marine solution of tin. M. Le Pileur d'Apligny advises the addition of some vinegar to the sugar of lead, in order to prevent the precipitation which is formed, when it is dissolved in water.

When the cotton is taken out of the mordant, it is slightly wrung with the pin and dried; the colour is more beautiful as the drying is slow. They generally dye only twenty pounds of cotton at a time; it is better to dye even only ten, because when too great a number of hanks are wrought in the copper it is much more difficult to dye them equally.

A copper in which ten pounds of cotton are to be dyed, should hold about two hundred and forty quarts of water, which must be heated; when almost too hot for the hand, six pounds and a quarter of good Dutch grape madder are to be added, and carefully dispersed through the bath. When it is well mixed with it, the cotton, which has been previously put upon the sticks and placed at the edge of the copper, is to be immersed hank by hank. All the cotton being put into the bath, it is to be worked, the hanks on each of the sticks being turned for three quarters of an hour, and the bath kept constantly at the same degree of heat without boiling. At the expiration of this time, the cotton is taken out and placed on the edges of the copper, a pint of the above ley of soda is to be added to the bath; the cotton is then to be returned into the bath, and boiled from twelve to fifteen minutes; lastly, it is to be taken out and left to drain, wrung, washed in a stream of water, and wrung on the pin a second time.

Two days afterwards, the cotton receives a second maddering in the proportion of eight ounces to the pound, and is worked about as in the first maddering, with this difference, that no ley is added, and that well water is employed for the bath: this maddering being finished, the cotton is left to cool, washed, wrung, and dried.

M. Le Pileur d'Apligny does not think this method of dyeing by two baths a good one, because it requires more time and fuel, and because the second maddering cannot furnish much dye, the salts of the mordant having been exhausted by the first. He proposed another method, in which he says several dyers

dyers have already succeeded; it consists in aluming the cotton twice, and then dyeing it by one bath only.

In order to render this red more lively, a quantity of warm water, sufficient to moisten the cotton, is put into a caldron or vat, into which about a pint of the ley is to be poured; the cotton is to be soaked in this bath, pound by pound, left there for a moment, taken out, wrung, and dried. According to M. Le Pileur d'Apigny, this operation is uselefs; for, as the red cotton is intended for making stuffs, from whence it is necessary to separate the preparation when they are to be wrought, the colour of the cotton is at the same time rendered more lively, because it is passed through warm water rendered more active by the addition of a little ley. When the stuffs are taken out of this water, they are washed in a stream, and spread upon the grafs, where the red brightens more than it would do by any other operation.

The red in printed stuffs is likewise produced by madder, but it must be fixed by a mordant. Mr. Wilson describes that which is used for this purpose, as follows: In four pounds of hot water (some employ lime water) three pounds of powdered alum, and one pound of saccharum saturni, are to be dissolved; this solution is put into a vessel sufficiently large to allow of the effervescence which takes place, and two ounces of powdered chalk, two ounces of pot ash, and two ounces of sublimate, or corrosive sublimate, are to be added. This mixture must be well stirred and suffered to settle; the clear liquor must then be decanted, or, which is better, filtered.

With this liquor, coloured with the decoction of brasil wood, they print, and pass the stuff through hot water in which cows dung has been dissolved, in order to take away the starch or gum, used to give consistence to the mordant; they then carefully wash it, and put it into a madder bath. All the stuff becomes coloured, but that which has not been fixed by the mordant is destroyed, by alternately boiling with bran, and exposure on the grafs.

Mr. Oberkamf uses the same ingredients for the mordant, except that he does not put into it any corrosive sublimate. We have seen by Mr. Vogler's experiments, that that metallic salt rendered the colour of the madder more durable, and at the same time deeper.

The reader may here recollect, that alum is decomposed by sugar of lead, and that there results from the decomposition an acetite of alumine, while the lead combined with the sulphuric acid forms an insoluble salt, which remains in the sediment. The alkali and the chalk serve to take up the superabundant acid, which would weaken the colour of the madder, and give it a yellow tinge.

Mr. Wilson directs the use of this mordant, which is known by the name of printers mordant, and which is the same which Mr. Watt refers to in the experiments above mentioned, relative to the dyeing cotton red: according to his process, it must be galled, dried, impregnated with the mordant, diluted with hot water, dried a second time, maddered, washed, and dried again.

The Adrianople red possesses a degree of brightness, which it is difficult for us to approach by any of the processes hitherto mentioned; it has likewise the property of resisting much more powerfully the action of different re-actives, such as alkalis, alum, soap, and acids. Mr. Vogler confesses that, by his numerous processes, he has not been able to obtain a red of a degree of permanency equal to that of the Adrianople red, though he has much excelled in this respect the false Adrianople reds, used for Siamese (siamoisés) and other stuffs. It is necessary to remark, that soap suds weaken and destroy the most durable madder colours,
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even that of the Adrianople cotton : hence it appears, that we ought as much as possible to be sparing in the use of soap, in the washing of thread and cotton of this colour. The only difference between the true and false Adrianople red is this, that the one resists these influences much longer than the other. Aqua fortis, or dilute nitrous acid, is according to Mr. Vogler the best and most expeditious test, for distinguishing the true Adrianople red from the false. If we immerse a thread of the latter dye in it, it soon becomes pale, and in less than a quarter of an hour white ; while the true Adrianople red will remain in it for an hour without any alteration, and indeed never entirely loses its colour, which acquires an orange hue.

The Adrianople red, which for a long time came to us by our Levant trade only, excited the industry of our artists ; but their attempts were for a long time fruitless, or their success confined to a very few manufactories. The Abbé Mazéas published some experiments which threw considerable light on this kind of dye ; and the French Government, from the information it received, published in 1765, an instruction under the title of, A Memoir containing, the Process for Dyeing Spun Cotton of the same Scarlet Red as that of the Adrianople Cotton. We find the same description in M. Le Pileur d'Apligny's treatise, but the process has not succeeded completely ; the fault seems principally to have consisted in making the alkaline solution too strong. The alterations made in different manufactories, with more or less success, have been kept secret. For the following description, Berthollet was indebted to Mr. Clerc, who has the management of a manufactory at Vaudreuil, and who sent him a pattern of his cotton, which was dyed of a beautiful and durable red.

Process for the Adrianople or Turkey Red.

When a hundred pounds of cotton are to be dyed, we must begin by scouring it well. This operation consists in boiling the cotton in a ley of soda, marking one degree of the areometer, to which is commonly added the remainder of the bath which has been employed for passing the cottons through, for the white preparation (en l'apprêt blanc), which is called sickiou.

In order to scour the cotton properly, and prevent it from entangling, a cord is passed through three hanks (the hank is composed of four knots (pentes), each of which weighs a quarter of a pound, making the hank equal to a pound), and it is thrown into the ley when it begins to boil ; it is carefully immersed, that it may not be scorched by the upper part of the caldron, which should contain about one hundred and fifty gallons of water for one hundred pounds of cotton ; the cotton is completely scoured when it sinks of itself in the caldron ; it is then taken out, and washed knot by knot in the river, wrung, and hung out to dry.

Second Operation ; Bath with Dung.

A hundred pounds of Alicant soda (barilla) in coarse powder are put into a tub with a hole near its bottom, to allow the water to run into another tub placed under it ; seventy-five gallons of lixivial water are poured on the soda in the upper tub : when the water which has run into the lower one marks two degrees of the soap-makers areometer, it is proper for the bath with dung, which is made in the following manner :

Twenty-five or thirty pounds of sheep dung are mixed with the above ley in a large earthen vessel, and stirred with a wooden pestle, then passed through a hair sieve placed over the vat in which the bath is to be prepared ; twelve pounds

and a half of Provence oil are then poured into the vat, and kept constantly stirring with a rake, that it may be perfectly mixed with the ley and the dung; the foda ley is poured upon it; nine buckets of water (each equal to four gallons) are commonly required for a hundred pounds of cotton. The bath being thus prepared, is in a proper state to receive the cotton. For this purpose, some of the bath is taken in a wooden bowl, and poured into an earthen pan set in brick-work at a proper height for working. A hank of cotton is taken and well wrought with the hands; it is frequently taken up and turned in the pan, and then hung upon a wooden hook fixed to the wall; it is slightly wrung out, and thrown upon a table; and the same operation is repeated with each hank. The table upon which the cotton is thrown ought to be raised eight or ten inches from the ground. A workman takes a hank in each hand, and strikes it on the table to stretch the threads; he turns it three times, and then makes a small twist to form a head for the hank, and lays it upon the table; not more than three hanks should be placed one upon another, as too great a weight would squeeze the bath out of the under hanks. The cotton ought to remain ten or twelve hours on the table, and then be hung out to dry.

Third Operation; Bath with Oil, or White Bath.

Ley of foda also at two degrees of the areometer is taken; and after the vat in which the bath with dung was made has been well cleaned, twelve pounds and a half of olive oil are put into it, and the ley of foda added, while it is kept constantly stirred with a rake, in order to mix the oil completely. This bath ought to resemble thick milk; and that it may be good, it is necessary that the oil should not rise to the surface: some of this bath is then put into the pan, and the cotton dipped hank by hank, as in the former operation; it is thrown on the table, and beat upon it, which is called *crêper*; it is left there till the next day, and then hung out to dry. For this bath about eight buckets of ley are required.

Fourth Operation; first Salt.

Fresh foda is added to the remainder of that first put into the tub, if the water poured upon it has not attained three degrees. For this operation, eight buckets of ley are poured into the vat upon the remains of the white bath, and the cotton is passed through it in the same manner as before. This operation is called giving it the first salt (*donner le premier sel*); the ley being at three degrees.

Fifth Operation; second Salt.

The cotton is passed through a ley of foda at four degrees, the working being conducted as before described.

Sixth Operation; third Salt.

The cotton is passed through a ley of foda at five degrees.

Seventh Operation; fourth Salt.

The cotton is passed through a ley of foda at six degrees, the same precautions being observed, and then carried out to be dried on very smooth poles; when dry, it is taken to the river to be washed in the following manner.

Eighth Operation.

The cotton must be first soaked in the water, then taken out and put upon the horse (*bayard*) to drain; water is repeatedly thrown on it, that it may be well soaked, and an hour after it is washed knot by knot, to free it completely from
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the oil, which is absolutely necessary to its taking the galling well; it is then wrung with the jack and pin, and stretched upon the poles to dry: the cotton when thus washed ought to be of a beautiful white.

Ninth Operation; galling.

For the galling, we must choose good galls in forts (a term employed in commerce, to denote black and white galls mixed together in equal quantities), and having bruised them, put for each hundred pounds of cotton, twelve pounds and a half into a copper, and boil them in six buckets of clear river water. Three hours are generally required to boil them sufficiently; we perceive, that this is accomplished when they break between the fingers like bouille; three buckets of cold water are then added, and the whole passed through a very close hair sieve, squeezing with the hand what has not passed through, in order to separate all the refinous particles. When the water has settled and become clear, the galling is to be performed in the following manner:

Nine or ten quarts of the galling are poured into an earthen pan set in the wall at a height convenient for working, and the cotton is dipped in it by separate hanks, working it well with the hands; it is then wrung with the pin, and carried out to be dried as fast as it is dipped; a precaution essentially necessary to prevent the cotton from growing black.

When the cotton is thoroughly dried, we proceed to the aluming, in the following manner:

Tenth Operation; aluming.

The copper in which the decoction of galls was made being well cleaned, eight buckets of river water and eighteen pounds of Roman alum are put into it, and the alum dissolved without boiling: when the solution is complete, half a bucket of soda ley at four degrees of the areometer is added, and the cotton then wrought in it, hank by hank, as in the galling; it is then spread out to dry, and afterwards washed from the alum as follows:

Eleventh Operation; washing from the Alum.

Having left the cotton to soak and drain for an hour upon the horse, each hank is washed separately three times, wrung with a pin, and carried to the tenter ground.

Twelfth Operation (remonter sur Galle).¹

This operation consists in a repetition of the former ones. A white bath is prepared similar to that described in article 3; twelve pounds and a half of good Provence oil are put into a vat, and eight buckets of ley, at two degrees of the soap-makers areometer, added to it; and the bath being well stirred, the cotton is dipped in the manner described in article 3.

Thirteenth Operation; first Salt.

The cotton, after being well dried, is dipped in a ley at three degrees.

Fourteenth Operation; second Salt.

After the cotton has been well dried, it is dipped in a ley at four degrees.

Fifteenth Operation; third Salt.

When the cotton is again dry, it is dipped in a ley at five degrees, and this concludes the dips: after being dried, it is washed, galled, and alumed, with the same proportions, and attention to the same circumstances as in articles 9, 10, and 11. The cotton has now received all the preparations necessary for taking

taking the dye, and ought to be of the colour of the bark of a tree. A very essential circumstance to be attended to, is, never to dip the cotton till it is perfectly dry, otherwise we run the risk of rendering the colour spotted. When the cotton is hung out upon the poles, it must be frequently shaken and turned to make it dry uniformly.

Sixteenth Operation ; the dyeing.

A copper of an oblong square form is generally employed, which ought to be capable of holding about one hundred gallons, in which quantity twenty-five pounds of cotton may be dyed at once. The process for dyeing is begun by filling the copper with water within four or five inches of the brim, and pouring in a pailful of bullock's blood, or, what is still better when it can be procured, sheep's blood (this is equal to about five gallons), and then adding the lizary. When we wish to obtain a fine bright colour, which penetrates, and has a good body, we commonly mix several kinds of lizary together, as one pound and a half of lizary of Provence, half a pound of lizary of Cyprus; or, if these cannot be had, a pound of that of Provence, with as much of the lizary from Tripoli or Smyrna, allowing always two pounds for one of cotton. When the lizary is in the copper, it is stirred with a rake, to break the clods or lumps; and when the bath is warm, the cotton is put in on skein sticks, two hanks commonly on each; care must be taken to immerse it properly, and to turn the cotton on the skein sticks, by means of a pointed stick passed along them within the hanks. This process is continued for an hour; and when the copper begins to boil, the cotton is taken off the skein sticks, and immersed in it, each hank being suspended by means of a cord passed through it, to sticks supported over the copper. The cotton ought to boil about an hour, in order to extract all the colouring matter from the madder. There is also a method of discovering when the colour is extracted, by the formation of a white froth on the copper. It is now taken out, and washed knot by knot at the river, wrung with the pin, and dried.

Seventeenth Operation ; brightening.

Soda ley at two degrees is poured into the copper used for scouring, which should hold a hundred and fifty gallons of water, and it is then filled within ten or twelve inches of the brim; four or five pounds of olive oil are then added, and six pounds of white Marseilles soap cut very small; it is kept stirring until the soap is dissolved; and when the copper begins to boil, the cotton is put in, a cord being previously passed through it to prevent its being entangled: the copper is then covered up, and stopped with rags, loaded and made to boil gently for four or five hours: the cover being now taken off, the cotton should appear finished, and of a beautiful red. The cotton must not be taken out of the copper for ten or twelve hours, because it improves in the bath, and acquires a much greater degree of brightness.

It must be well washed knot by knot, and dried, and the operation is complete.

Berthollet used to give his cottons a dip after they were quite dry; he made a solution of tin in aqua fortis, taking for a hundred pounds of cotton three or four pounds of aqua fortis at twenty-six degrees*, to which he added an ounce of sal ammoniac for each pound, and then dissolved in it six ounces of fine tin in grains; he added to the bath a pound and a half of mineral crystal; he then

* To distilled water as 1220 to 1000. Hamilton.

diluted the mixture with eight buckets of water, and dipped his cotton, which must then be washed; this dip gives the cotton a very fine fire (feu).

N. B. Only the residua of the first preparations are to be put into the sickiou; those which remain after the cotton has been galled are of no use, and must be thrown away.

Mr. Gren has published some experiments which throw a great deal of light on the theory of the Adrianople red *. He took two ounces of spun cotton, on which he poured fresh oil, and left it to soak for fifteen days, taking care to work the cotton well with it from time to time; he then squeezed out the oil as much as possible, and put the cotton into a boiling solution of barilla. After boiling it for half an hour, he poured out the ley, which had a milky appearance, and supplied its place with fresh urine, in which he boiled the cotton for a quarter of an hour; but he has ascertained, that water may be substituted for the urine. He made a decoction with half an ounce of alum and two drams of sumach, and put the cotton which had been well washed into it while boiling hot, and kept up the ebullition for an hour: after which he let it cool, and kept the cotton in it twelve hours: when taken out of this bath, it was dried in the shade, washed in cold water, and dyed with a decoction of half an ounce of madder; he chose whole roots of madder the most slender he could find, cut them into small pieces, and pounded them. He left the cotton to grow cold in the bath. When washed it shewed a very fine colour, which differed from the true Turkey red cotton only in lustre, which it did not possess in so high a degree, but it sustained the same proofs: thus it retained its colour after being washed in boiling water: the brightness of the colour was increased by washing in a cold ley of ashes; vinegar did not change it; exposure to the sun and air for three weeks produced no sensible alteration in it.

Ground madder of a middling quality produced, under similar treatment, a dirty brown colour without any brightness; but Zealand madder of a good quality produced a colour similar to the former.

The addition of fixed alkali, even in small quantity, to the decoction, produced a deeper colour. The addition of solution of tin gave the colour a more pleasing hue.

Mr. Gren obtained only a bad colour, which simple washing discharged, when he used pure or caustic pot-ash instead of soda; but carbonat of pot-ash succeeded as well as soda, when care was taken to squeeze out the oil from the cotton previous to its being put into the solution of the salt: if the oil was not squeezed out, the colour was but indifferent: whence he infers, that the alkali ought not to be so caustic as to deprive the cotton entirely of the oil, while at the same time it ought to possess sufficient activity not to allow it to retain too much. These experiments also evinced, that in order to produce a red similar to that of Adrianople, it was necessary to choose the best kind of madder, and to prefer the whole roots, rejecting those which are too old, too woody, or rotten. When he employed different kinds of the ground madder, he most commonly obtained a dark brown colour instead of a red, notwithstanding all the attention he could employ in the coction.

Berthollet, after having repeated the process of Mr. Gren, and a great part of the numerous and interesting experiments of Mr. Vogler, gives the following account of some others of his own.

* Crell, *Neueste Entdeckungen*, vol. iii.

The acetite of alumine, formed by the mixture of alum and the acetite of lead or salt of saturn, proved to be a better mordant than alum for fixing the colour of madder, and was still more efficacious when it contained an excess of acid, as it is prepared for the printing of linens, and as Mr. Wilson directs.

Alum saturated with pot-ash to such a degree as to afford a slight sediment, was also a much more efficacious mordant than alum, probably for the same reason. Solution of arsenic in pot-ash produced a similar effect, and even seemed to be superior.

Galling renders the colour more fixed, and appears to darken it a little; yet galling is employed in the Adrianople process. Galls cannot be mixed with madder, because they prevent the extraction of its colouring part. Berthollet always began his processes by galling, after having leyed the cotton.

Leying renders the cotton more disposed to become saturated with colour.

Berthollet made the same observation as Mr. Vogler, that mucilages and gums render the colour more fixed, but that glue in particular produces this effect: it combines with the alumine and the cotton, and thus imparts to the cotton the property of animal substances.

Complete exsiccation between each of the processes is very useful: when the water is expelled, its attraction no longer opposes the combination or decomposition of the mordant to which it proved an obstacle. It appeared to Berthollet a matter of indifference whether the exsiccation was quick or slow, provided however it was not too rapid, because of the crystallizable salts, the alum for example, for then, the solution exudes before it is decomposed, and crystallizes on the surface; in which case the dyers say that it has run. This is probably the reason for directing that the exsiccations should be conducted in the shade, and not in the sun.

Berthollet found that long maceration and long continued boilings with the mordant were useless, and that it was sufficient if the cotton was well impregnated with the mordant: it appeared to him, for example, that no greater effect is produced by repeating the aluming two or three times successively, than by one operation properly conducted.

If only the saturation and permanency of the colour were attended to, we should from the experiments of Berthollet begin by leyed the cotton, galling, drying, and soaking it in the mordant composed of alum and the alkaline solution of arsenic, or in the saturated acetite of alumine; we should then dry it, soak it in a solution of glue, dry, and wet it, that it may not take the colour unequally, and lastly, dye it in a madder bath containing glue. If we add common salt to one of the first preparations, the dye is still stronger (plus forte); but the colour obtained in this manner, and by similar processes, is browner and much less bright than the Adrianople red.

Of the two processes by means of which Berthollet came nearest the Adrianople red, without using a consistent oil, the one was by employing as mordant, a solution in the nitrous acid of the precipitate from alum by common pot-ash; the other was by adding calx of tin to the madder bath. By this last process, Berthollet obtained a red which might easily be taken for that of Adrianople.

He repeated the process of Mr. Gren with success, substituting galls for the fumach; but the colour which he obtained, and which came very near the Adrianople red, withstood the action of leys, soap, and the air, less powerfully.

We have seen that Mr. Vogler had not succeeded by impregnating the cotton with oil; and yet without a greasy substance, we cannot obtain a colour like the Adrianople red. The intestinal liquor of sheep, employed in the Adrianople process under the name of *sickiou*, seems to act by means of the grease which it contains, and by a substance analogous to the ferosity and gluten found in all animal substances.

Mr. Pallas relates in the Petersburg Journal for 1776, that the Armenians, whom the troubles in Persia obliged to retire to Astracan, dye Turkey red by alternately impregnating the cotton with fish oil, and drying it, for seven days; that they have observed that other oils do not succeed; and that they do not even use the oil of all fish indiscriminately, but choose that which becomes milky upon being mixed with an alkaline solution. After these repeated impregnations and exsiccations, they wash the cotton and dry it: they then give it an astringent bath to which a little alum is added; they dye it in a madder bath with which calves blood has been mixed; finally, they digest it for twenty-four hours in a solution of soda. It would seem that Mr. Vogler had not remarked, that the cotton should be deprived of the oil only to a certain degree by means of the ley.

The following observations prove that, in the Adrianople red, the cotton has retained a little of the oil. A skein of cotton having been soaked in soap suds, and wrung slightly, was dried, and then immersed in a mordant of alum saturated with pot-ash, afterwards dried, and dyed; it had only a well saturated madder colour: after two minutes boiling in weak soap-suds, it came out with the shade of Adrianople red: its durability was not examined.

If cotton dyed with madder in any way be boiled for some minutes in soap suds, it acquires a rose colour (*rosé*); if it be then squeezed, a greasy matter is pressed out, which has the colour of Adrianople red, and which fixes on white cotton. Mr. Oetingen had observed* in 1764, that oil had the property of dissolving the colouring matter of the Adrianople red, so that, if it be moistened with oil, its colour is communicated to white cotton when rubbed with it for some time. He had thence concluded, that oil must enter into the preparation of Adrianople red; and the Abbé Mazéas has long ago proved that the use of oil in that dye was indispensable†.

The kind of madder employed has great influence on the colour produced. It appears absolutely necessary to employ that which is called *lizary*, in order to obtain a colour equal to the Adrianople red.

With respect to the choice of madder, we must recollect that Messrs. D'Amourney and Beckmann recommend the use of fresh madder; but it is generally supposed that it gives a more beautiful colour, when kept for a year or two before it is used; and Mr. Gubliche says, that the old madder gives a colour nearly as beautiful as *lizary*. There are cases perhaps in which the use of fresh madder would be advantageous; the choice of the young roots would certainly be proper.

Berthollet having exposed for a long time to the inclemencies of the weather, the cotton which he had dyed with the addition of calx of tin to the madder bath, that, for which the solution of alumine in nitrous acid had been employed as mordant, and a pattern of Adrianople cotton; the colour of the first remained

* Dissert. de Viribus Radic. Rubiæ Tinct. Antirachiticis a Virtute Ossæ Animal. vivorum tingendi non pendentiibus.

† Recherches sur la Cause Phys. de l'Adhërence de la Couleur Rouge, &c. Mem. des Sav. Etrang. tome iv.

longest without any sensible change; at last however it acquired a yellow hue; the second acquired a yellowish tinge sooner; the colour of the third was impaired soonest, but it did not change its hue (ton).

From this experiment it follows, that we may consider in cotton dyed with madder, its power of resisting the action of the air for a long time, or that of resisting alkalis or soap. This last can only be obtained by means of oils and grease; but the first depends principally on the mordants employed, and the number of dryings. It is therefore proper, independent of the beauty of the colour, to employ processes similar to that of Adrianople, for such stuffs as are to be subjected to laying or frequent washing with soap.

Mr. Willson makes an observation which is worthy of attention. He says, that stuffs made of cotton which has not been spun by Mr. Arkwright's machines, cannot be dyed by the Adrianople process, because the filaments of the cotton are made to bristle up (se hérissent) in the numerous operations of this process; but that these filaments preserve their parallelism much better when the cotton has been spun and carded by these machines, and that the stuffs can then undergo the same operations without injury to their texture*.

But as colours which sustain the action of the air as well as the Adrianople red, may be obtained by shorter processes, and as cotton stuffs are not intended to be submitted to laying and frequent washing, processes analogous to some of those described above, may frequently be employed with advantage.

One circumstance which ought not to be omitted, is, that aerated marine acid represented the action of the air on the madder reds exposed to its influence, indicating the patterns which would resist its action most powerfully; while the nitrous acid on the contrary indicates the cotton dyed in the Adrianople manner, by giving it a yellow colour, as Mr. Vogler has observed: this effect seems to depend on the combination of the animal oil with the cotton, to which, as to all other animal substances, the nitrous acid gives a yellow colour by destroying the proper colour of the madder: it is this combination of animal oil with the cotton, which forms the distinguishing characteristic of this species of dye: a different kind of oil might produce a bright colour, but probably it would not be so durable.

Berthollet also tried the calx of tin in dyeing wool. The decoction of madder acquires a more clear and lively red by the addition of this calx; its colouring particles became fixed much more quickly and more abundantly, upon cloth which had been prepared by a decoction of alum and tartar in the ordinary manner. The cloth came out of the dye bath of a much more saturated and beautiful red, than a similar pattern dyed with an equal weight of madder, without calx of tin; the advantage however does not appear to me so great, as to render the process worthy of being commonly employed.

Calx of zinc used instead of tin, produced a fine orange colour in the cloth; calx of lead, a dull brick colour; that of iron had no sensible effect.

MAGISTERY. Chemists formerly applied this term to almost all precipitates; at present it is applied only to a few, which have retained the name, from habitual usage.

MAGISTERY OF BISMUTH. The calx of bismuth precipitated from its solution in nitrous acid by the addition of a large quantity of water. To make this preparation, which is a fine white powder, very pure bismuth must be dissolved

* An Essay on Light and Colours, &c.

in pure nitrous acid. To this solution a large quantity of water, the purer the better, must be added. The whole immediately becomes of a milky white, by the diffusion of the calx, which separates, and at length subsides; the clear fluid must then be decanted off, and the calx thrown upon a filtre, to be edulcorated by repeated affusions of water. Some artists precipitate the bismuth by a fixed alkali, but in this way the magistery is not so white; probably from the impurity of most common alkalis, or perhaps from the state of the calx itself, which may carry down fixed air.

The chief use of the magistery of bismuth is to enter into the composition of white paint used by ladies. It is preferred to all other whites from its superior beauty, its lustre, and an almost insensible tint of carnation, which renders it more similar to the finest and whitest skin.

MAGISTERY OF CORAL. This name has been given to the calcareous powder obtained by dissolving coral, crabs-claws, chalk, or other substances of the like nature, in nitrous acid, precipitating with a fixed alkali, and washing the precipitate in a sufficient quantity of water.

MAGISTERY OF SULPHUR. The powder of sulphur which is thrown down from a solution of liver of sulphur, by the addition of an acid.

MAGNESIA. See **EARTH MAGNESIAN.**

MAGNESIA BLACK. Modern chemists are agreed in using the denomination manganese for this substance, which see.

MAGNET. The loadstone. When a bar of iron or steel is rendered magnetical, it is called an artificial magnet. The usage of modern writers has almost entirely confined the word magnet to this last instrument. It is useful to the chemist in making an inaccurate separation of substances containing iron from pulverized mineral matters, after a slight calcination.

MAGNETISM. The property by which iron exhibits a peculiar and strong attractive and repulsive power upon other iron, according to circumstances. For the general facts, recourse must be had to writers on natural philosophy, as they do not particularly appertain to the chemical department. All iron whose dimensions in length greatly exceed its other dimensions is very evidently magnetical, while held in a vertical position in these latitudes; but the property diminishes and disappears the more that position is altered. Properly speaking, the position most favourable for this magnetism is not the vertical one, but that which a magnetical bar truly poised, and at liberty to assume any position, is disposed of itself to take when this power is communicated to it. It is observed, that the magnetism of mere position becomes permanent in bars of iron which have long remained vertical; and that heating and cooling, indentation by blows, filing, the electrical shock, or any other cause which may agitate the whole mass, while in this situation, will render the magnetism permanent; and accordingly it is found that the poker, tongs, and other similar utensils, soon acquire a fixed magnetism by use. The magnetism of three equal bars of steel may be rendered much more considerable by a manipulation called the touch, which appears to depend on this principle, that a single weak bar, will become stronger in its power by being rubbed at the same time by two other weak bars; that one of the two touching bars being then subjected to the touch from both the others, will become stronger than the bar first touched, by reason of the superior power of the touching bars, one of which had its energy increased by the preceding operation; that if the untouched bar be then laid down and subjected to the touch from the two others, it will, upon the same principle, become the strongest of the three: and, by

by repetitions of this process, all the bars may be brought to a greater degree of magnetical power than they are capable of retaining. What happens in these processes, as well as in every thing else relating to magnetism, is so entirely unknown, that we do not possess even a probable hypothesis on the subject.

MALACHITE. A solid green copper ore, which is sometimes cut and polished as a gem. It has the appearance of green jasper; but is not so hard, since it does not strike fire with steel. It is either of a radiated or uniform texture, generally of an oval form, and of the size of an egg; but sometimes it is formed of capillary filaments, like satin, and shews a kind of concentric stripes, or shreds, of paler colours, when cut and polished; its external appearance is like a thick shell, with various protuberances of a mamillary form. The silky-green copper ore of this kind from China, in the form of solid bundles, is the purest. It is found also in great quantity on the Vosges, mountains so called in Lorraine, and in the mines of the Harz in Saxony.

According to Kirwan, the purest malachite contains 75 parts of copper, and 25 of aerial acid. Its specific gravity, according to Musschenbroeck, is from 3,500 to 3,994. It is sometimes mixed with calcareous earth and gypsum, and is found in Norway and Siberia. **KIRWAN.**

MANGANESE. The regulus of manganese is a semi-metal of a dull whitish colour when broken, but soon grows dark by calcination from the action of the air. It is hard, brittle, though not pulverizable, and rough in its fracture; so difficultly fusible, that no heat yet exhibited has caused it to run into masses of any considerable magnitude, and it appears to be more disposed to calcination than any other metallic substance, unless we may except wolfram. Its calces are white when imperfect, but black, or dark green, when perfect: the white are soluble in acids. When broken in pieces, it falls into a powder by spontaneous calcination; and this powder is magnetic, though the masses were not possessed of that property. It seems as if the regulus of manganese were capable of depriving a small proportion of iron of its magnetism, but that the effect ceases as soon as that regulus is converted into calx: a strong heat expels vital air from the calx of manganese.

Concentrated vitriolic acid attacks the regulus of manganese, but much more readily when diluted with two or three times its weight of water; at the same time that inflammable air is disengaged. A black spongy substance remains undissolved, which has not been examined. The solution is colourless, and affords crystals by evaporation. Mild alkalis precipitate a white calx soluble in acids; but pure alkalis afford a brown calx, which soon grows black in the air, and is scarcely soluble. The black calx of manganese, when old, or well made, is altogether insoluble in acids, unless some combustible substance be added. It appears, therefore, that the metal in this state is too far calcined, and requires to be reduced again in a certain degree towards the metallic state, to be dissolved. If vitriolic acid be added, and drawn off by distillation several times from the black calx, by a heat nearly approaching to ignition, in a glass vessel, it is found that vital air is disengaged towards the end of each process, and part of the calx is dissolved. The solution of the calx in acids, by the addition of combustible matter, is easily accounted for, on either of the theories of chemistry, by affirming that the reduction is effected by the addition of phlogiston, or the subtraction of vital air from the calx, by means of the combustible substance. The phlogistic theory appears, however, to be deficient, in explaining the solution by mere vitriolic

vitriolic acid, at an elevated temperature*, on account of the absence of phlogiston; but the new theory simply asserts the facts, that the calx loses vital air in consequence of the elevated temperature, and is rendered soluble in the acid.

Nitrous acid dissolves the regulus of manganese with effervescence, and the escape of nitrous air. A spongy, black, and friable matter remains, whose properties resemble molybdena. The solution does not afford crystals. The perfect calx is not soluble in pale nitrous acid, unless some combustible matter be added.

The regulus is dissolved in the usual manner, by marine acid. The black calx is likewise soluble; but adheres so weakly to the acid, as to be separated even by the mere addition of water: but, if this solution be exposed to a digesting heat for some hours, an intestine motion, like an effervescence, takes place; the smell of dephlogisticated or aerated acid is perceived, and the combination becomes more perfect, so as not to afford a precipitate, unless an alkali be added. Marine acid dissolves the black calx also, by the addition of a combustible substance: mercury, and even gold, will effect this combination. The solution of manganese in marine acid scarcely affords crystals; but a deliquescent saline mass by evaporation, which is soluble in ardent spirit.

In the permanent solution of black calx of manganese by marine acid, it is seen that the acid itself must communicate the property to the calx, on which its solubility depends; that is to say, it must either afford phlogiston, or absorb vital air: and accordingly the red vapours which escape are distinguished by the name of dephlogisticated, or aerated, marine acid, according to the theory which may be adopted by the speaker.

Other acids likewise dissolve this metallic substance: the fluor acid, and also the phosphoric acid, form compounds of different solubility, which envelop and defend it from their farther action in a short time.

In the dry way, the calx of manganese combines with such earths and saline substances as are capable of undergoing fusion in a strong heat. These experiments are most advantageously performed by the blow-pipe, on small quantities of matter; because in this way the whole of the phenomena are clearly seen. The most remarkable property of the solutions is, that a due proportion of combustible matter renders them colourless; for which reason, the calx of manganese is used by the glass manufacturers to destroy the colours of glass. If a globule of microcosmic salt be fused by the blow-pipe upon charcoal, and a small portion of the black calx of manganese be added, the colour will be of a blueish red; or of a deep red, if the quantity of calx be greater. If the fusion be continued by the interior blue flame, the colour at length disappears; but may be easily revived again, by sustaining the globule with the exterior flame. A small particle of nitre instantly restores the red colour; but inflammable matter, or vitriolic salts, contribute to discharge it. If the globule, after being deprived of all colour, be fused in the silver spoon, it recovers its redness; and the colour is not discharged by any management of the fusion, unless some inflammable matter be added.

These remarkable changes of colour, which may be repeatedly produced, depend evidently on the presence or absence of combustible matter; or, which amounts to the same thing, on the degree of calcination of the manganese which is held in solution. When the highly calcined or black manganese is first added, it

* Bergman, ii. 215, (on the hypothesis, that heat is matter; that the matter consists of pure air united to the phlogiston; and that manganese decomposes the heat) derives the phlogiston required for the solution, as well as the vital air which flies off, from this decomposition. These positions do not appear to be sufficiently established.

produces a coloured globule; if inflammable matter be added, the calx is partly reduced, and forms a colourless combination: nitre restores the colour by its well-known property of calcining metals. When the fusion is performed by the interior flame, the globule may be considered as if heated in a close vessel, in contact with charcoal; because the surrounding flame prevents the access of air: a revival of the calx therefore ensues, and the colour vanishes. But when the external flame is used, its apex or point only touches the globule; and the surrounding air promotes or maintains the calcination more effectually than the charcoal can produce the contrary effect; the consequence therefore is, that the colour again appears. Vitriolic salts seem to forward the action of the charcoal, which converts them into sulphur; and the colour remains fixed in the spoon, because there is no combustible substance present, which is sufficiently so to promote the revival of the calx. It is evident, that both the theories of chemistry are applicable to these facts, whether the charcoal revives the calx by phlogisticating it, or by depriving it of its vital air; or whether the calcination by the apex of the flame be effected by the dissipation of phlogiston, or by the absorption of vital air from the atmosphere.

Nearly similar changes are produced when the calx is fused with borax, or an alkali.

Regulus of manganese does not appear to combine with sulphur; but eight parts of the calx combine with three of sulphur, and produce a yellowish green mass, which is acted upon by acids; the metal being dissolved with effervescence, and the disengagement of hepatic air. The remaining sulphur may be collected on a filter.

This semi-metal melts readily with most of the other metals, but rejects mercury. Gold and iron are rendered more fusible by a due addition of manganese; and the latter metal is rendered more ductile. Copper becomes less fusible, and is rendered whiter, but of a colour subject to tarnish*.

Regulus of manganese has been found native among the powdery or calciform ore of this metallic substance. Its properties, in this state, perfectly resembles the regulus produced by art. Manganese appears to exist in the calcined state in all its ores; though contaminated with admixtures of earths, or other metallic matters. They are white, red, brown, or black; either pulverulent, indurated, or crystallized. Vegetable ashes likewise afford indications of manganese.

To analyse the ores of manganese in the humid way, they must be reduced to a subtle powder, and immersed in a mineral acid, with a piece of sugar to assist the solution. If nitrous acid be repeatedly abstracted to ignition from the ore, the iron it contains will be rendered nearly insoluble from calcination, and the manganese may be taken up by strong concentrated vinegar, or diluted nitrous acid. This, when precipitated by mild mineral alkali, affords 180 grains of precipitate for every 100 grains of regulus: or if the metals be precipitated from superabundant nitrous acid, by Prussian alkali, the manganese will be totally dissolved by pure water, while the iron remains behind.

The ore of manganese, which is known in Derbyshire by the name of black wadd, is remarkable for its spontaneous inflammation with oil. It is of a dark brown colour, of a friable earthy appearance, partly in powder, and partly in lumps. If half a pound of this be dried before a fire, and afterwards suffered to cool for about an hour; and it be then loosely mixed or kneaded with two ounces of linseed oil; the whole, in something more than half an hour, becomes gra-

* Annales de Chimie, i. 303.

dually hot, and at length bursts into flame. This effect wants explanation. It seems, in some measure, to resemble the inflammation of oils by the nitrous acid.

The presence of manganese may be ascertained in the dry way by the blow-pipe, from the singular changes of colour already described, when fused with microcosmic salt, or borax. The reduction of the ore is effected by mixing it with pitch, making it into a ball, and putting it into a crucible lined with powdered charcoal, one-tenth of an inch thick at the sides, and one-quarter of an inch thick at the bottom; then filling the empty spaces with powdered charcoal, and luting on a cover. This must be exposed to the strongest heat of a forge, or furnace, for an hour, or more. As the calx of manganese is strongly disposed to vitrification, fluxes rather impede than forward the reduction. The reduced globules of manganese are usually enveloped with a vitrified crust, which either partly or completely defends them from the action of the air; but, when they are broken, they lose their metallic brilliancy and consistence in a very short space of time.

Manganese has hitherto been used chiefly by glass-makers and potters; but the important discoveries of the uses of dephlogisticated or aerated marine acid will, no doubt, extend its utility to several other manufactories*. See ACID, MARINE AERATED, also BLEACHING.

MANNA. Several vegetables afford manna; it is extracted from the pine, the fir, the maple, the oak, the juniper, the fig, the willow, the olive, &c. but the ash, larch, and the alhagi, afford it in the largest quantities. Lobel, Rondelet, and others, have observed at Montpellier, upon the olive trees, a kind of manna, to which they have given the name of oeliomeli. Tournefort collected it from the same trees at Aix and at Toulon.

The ash which affords manna grows naturally in all temperate climates; but Calabria and Sicily appear to be the most natural countries to this tree; or at least it is only in these countries that it abundantly furnishes the juice called manna in commerce.

The manna flows naturally from this tree, and attaches itself to its sides in the form of white transparent drops; but the extraction of this juice is facilitated by incisions made in the tree during summer: the manna flows through these apertures upon the trunk of the tree, from which it is detached with wooden instruments. Care is likewise taken to insert straws, or small sticks of wood, into these incisions; and the stalactites which hang from these small bodies are separated, and known in commerce by the name of Manna in Tears: the smallest pieces form the manna in forts or flakes, and the common or fat manna is of the worst quality, because the most contaminated with earth and other foreign substances. The ash sometimes afford manna in our climates; specimens of which Chaptal saw collected in the vicinity of Aniane.

The larch, which grows abundantly in Dauphiny and the environs of Briançon, likewise affords manna. It is formed during the summer on the fibres of the leaves, in white friable grains, which the peasants collect and put into pots, which they keep in a cool place. This manna is of a yellow colour, and has a very nauseous smell.

The alhagi is a kind of broom, which grows in Persia. A juice transudes from its leaves in the form of drops of various sizes, which the heat of the sun indurates. An interesting account of this tree may be seen in Tournefort's Travels. This manna is known in the Levant, in the town of Tauris, by the name of Tereniabin.

* On manganese, consult Scheele, 67—142; Bergman, ii. 201—225; the Memoirs of Pelletier, Berthollet, &c.; and the Abstracts by Elementary Writers on Mineralogy.

The manna most frequently used is that of Calabria. Its smell is strong, and its taste sweetish and nauseous: if exposed on hot coals, it swells up, takes fire, and leaves a light bulky coal.

Water totally dissolves it, whether hot or cold. If it be boiled with lime, clarified with white of egg, and concentrated by evaporation, it affords crystals of sugar. See SUGAR.

Manna affords, by distillation, water, acid, oil, and volatile alkali: its coal affords fixed alkali.

This substance forms the basis of many purgative medicines.

MARBLE. All calcareous stones which are hard, of a close texture, and beautiful appearance, from the clearness and uniformity of their colour, or from its variety and admixture, are distinguished by the name of marble. For an enumeration of the several kinds, Cronstedt's Mineralogy may be consulted. The different names apply chiefly to circumstances of outward appearance, much more important to the statuary and the builder than to the chemist.

MARCASITE. This name has long been given indifferently to all sorts of minerals, to ores, pyrites, and to semi-metals. At present it seems to be confined to pyrites; and Wallerius proposes to apply it only to such pyrites as are regularly formed. This appears to be better than to leave it to a vague and indeterminate signification, from the ambiguity and obscurity which might thereby be introduced. The word is little used. See PYRITES.

MARGODES. A blueish grey stone, entirely resembling clay in its outward appearance, but so hard as to cut spars, or even zeolytes, though not to such a degree as to give fire with steel; dull in its fracture, its texture thick lamina, and of a conchoidal form; its specific gravity 2.877; it effervesces with acids. Kirwan found it to contain 50 per cent. of calcareous earth, about 32 of clay, 15 of silica, and two of iron.

MARLE. There are two kinds of marle; for which see EARTH, FULLER'S, the one consisting of clay divided by a very fine fuller's earth, and the common marle, consisting of clay divided by calcareous earth. Common marle participates in its properties of those of its respective component parts. When crude, it effervesces with acids; but does not after it has been burned. It hardens in the fire like clay, and the more so, the larger the quantity of clay which enters into its composition; but it falls into powder by exposure to the air like lime, and this the more readily, the greater the quantity of lime. A strong heat converts it into glass. See EARTH CALCAREOUS.

It is found either loose and friable, or more or less indurated. The semi-indurated marle is nearly as hard as a stone, when first dug up, but falls to pieces in the open air.

Marle is of excellent service for the improvement of lands, which it appears to do by altering the proportion of their component parts. See ARABLE LAND, and EARTH, VEGETABLE.

The English farmers distinguish six sorts of marle: 1. The coro-shut marle, which is brown mixed with fragments of chalk and blue veins. 2. Stone slate, or flag-marle: it resembles blue slate, and crumbles easily when exposed to the air. 3. Pont marle, or delving marle; it is brown, and rough to the touch. 4. Clay marle: which contains much clay. 5. Steel-marle: its colour is black, its consistence like that of bits of paper.

MARMOR METALLICUM. See SPAR PONDEROUS.

MARS. Chemists have distinguished iron by the name of the planet Mars, whence the term martial is still much used to denote compounds containing that metal.

MASSICOT. Yellow calx of lead. See MINIMUM.

MASTIC. A resinous substance in the form of white tears, of a farinaceous appearance, having little smell, and a bitter astringent taste. It flows naturally from the tree, but its produce is accelerated by incisions. The lesser turpentine tree and the lentiscus afford the mastic in commerce.

No volatile oil is obtained from this substance when distilled with water. Pure ardent spirit almost totally dissolves it; water scarcely acts upon it; though by mastication it becomes soft and tough, like wax. It is used in fumigations, in the composition of varnishes, and is supposed to strengthen the gums.

MATRASS. See APPARATUS.

MATRIX. The earthy or stony matters which accompany ores, or envelop them in the earth, are called the matrixes of those ores. They are various, and the information they afford to miners is not easily reducible to rule. It has been remarked, that it is generally found among crystalline or siliceous stones, and lead among those of the calcareous order.

MATT. Certain metallic ores, particularly that of copper, are distinguished by this name when partly deprived of sulphur, and fused into a mass with the remaining portion of that substance.

MATTER. When philosophers speak of the substance which composes the things around us, in the most general way, they use the term *matter*. This term is more abstract than the word *body*, which includes the consideration of limit; but it is less abstract than the words *being* or *thing*, which are applicable to substances which do not possess all the common properties of bodies, if indeed it be true, that any such substances exist.

MEASURES. The English measures of capacity are according to the following table.

One gallon, wine measure,	is equal to	four quarts.
One quart,	—	two pints.
One pint,	—	28,875 cubic inches.

The gallon, quart, and pint, ale measure, are to the measures of the same denominations, wine measure, respectively, as 282 to 231.

The French measures of quantity used by chemists:

The quart	is equal to	two pints.
The pint	—	two chopines.
The chopine	—	two demi-setiers.
The demi-setier	—	two porçons.
The porçon	—	four Paris ounces of water at the freezing point.

The proportion of the Paris ounce to the English troy ounce is, as 65 to 64.

As to the measures of length, it is sufficient to observe here, that the Paris foot is equal to 12.785 English inches, or to the English foot, as 114 to 107. For measures of weight, see BALANCE.

MELASSES. The juice of the sugar cane. See SUGAR. Treacle, or the residue after the separation of the crystals of sugar at the works, is exported to America and Europe, from the sugar islands, where it is fermented and distilled. The spirit thus obtained is called Melasses' spirit.

MENSTRUUM. A word synonymous with solvent.

MERCURY.

MERCURY is distinguished from all other metals by its extreme fusibility, which is such, that it does not take the solid state until cooled to the thirty-ninth degree below 0 on Fahrenheit's thermometer; and of course it is always fluid in the temperate climates of the earth. Its colour is white, and rather bluer than silver. In the solid state it is malleable*; its specific gravity is greater than that of any of the other metals, platina, gold, and wolfram excepted. It is volatile, and rises in small portions at the common temperature of the atmosphere, as is evinced by several experiments, more especially in a vacuum, such as obtains in the upper part of a barometer tube. At the temperature of about six hundred degrees it boils rapidly, and rises copiously in fumes. Few of the other metals melt at so low a temperature as the boiling point of mercury. When exposed to such a heat as may cause it to rise quickly in the vaporous form, it gradually becomes converted into a red calx, provided vital air be present. This is known by the name of precipitating *per se*. A greater heat however revives this metallic calx, at the same time that the vital air is again extricated.

Mercury is not perceptibly altered by mere exposure to the air; though by long agitation, with access of air, it becomes converted into a black powder or calx, which gives out vital air by heat, the metal being at the same time revived. This metal is disposed to attract moisture; and cannot, for that reason, be used in the construction of barometers and thermometers, until it has been first boiled in an open vessel for the space of about half an hour.

When mercury is agitated in a dry glass bottle, the friction between the metal and the glass produces electricity. If the bottle be imperfectly exhausted, this electricity passes into the vacuum, and produces a light, which was formerly thought to be a proof of the perfection of the vacuum in the upper part of barometer tubes; but which, in fact, does not appear in such barometers as have been cleared of air by careful boiling in the tube.

The vitriolic acid does not act on this metal, unless it be well concentrated and boiling. For this purpose mercury is poured into a glass retort, with near twice its weight of vitriolic acid. As soon as the mixture is heated, a strong effervescence takes place, vitriolic acid air escapes, the surface of the mercury becomes white, and a white powder is produced: when the vitriolic air ceases to come over, the mercury is found to be converted into a white, opaque, caustic, saline mass, at the bottom of the retort, which weighs one third more than the mercury, and is decomposed by heat. Its fixity is considerably greater than that of mercury itself. If the heat be raised, it gives out a considerable quantity of vital air, the mercury being at the same time revived.

The white mass produced by the action of vitriolic acid upon mercury, consists partly of a saline mass, or vitriol of mercury, and partly of a calx, or mercury united to vital air (simply, according to the new theory; or deprived of phlogiston, according to the old theory, which phlogiston is supposed to enter into the combination of the vitriolic acid air). Water separates the salt from the calx, which last is then of a yellow colour. Much washing is required to produce this colour, if cold water be used; but if a large quantity of hot water be poured on, the calx immediately assumes a bright lemon colour. In this state it is called turbith mineral.

* The reader will find an ample account of the freezing of quicksilver in Dr. Blagden's History, vol. lxxxiii. of the Philosophical Transactions.

The vitriol of mercury affords a salt by evaporation, in small needle-formed deliquescent crystals. The addition of a large quantity of water, more especially if heated, decomposes vitriol of mercury, which deposits turbith mineral, unless there be an excess of acid in the fluid.

The fixed alkalis, magnesia, and lime, precipitate mercury from its solution : these precipitates are reducible in closed vessels by mere heat without addition.

The nitrous acid rapidly attacks and dissolves mercury, at the same time that a large quantity of nitrous air is disengaged ; and the colour of the acid becomes green during its escape. Strong nitrous acid takes up its own weight of mercury in the cold ; and this solution will bear to be diluted with water. But if the solution be made with the assistance of heat, a much larger quantity is dissolved ; and a precipitate of calx will be afforded by the addition of distilled water, which is of a yellow colour if the water be hot, or white if it be cold ; and greatly resembles the turbith mineral produced with vitriolic acid : it has accordingly been called nitrous turbith. If acid be added to the solution made with heat, it loses its property of being decomposed by water. This decomposition is not complete, but only deprives the acid of the redundant calx.

All the combinations of mercury and nitrous acid are very caustic, and form a deep purple or black spot upon the skin. They afford crystals, which differ according to the state of the solution. When nitrous acid has taken up as much mercury as it can dissolve by heat, it usually assumes the form of a white saline mass. When the combination of nitrous acid and mercury is exposed to a gradual and long continued low heat, it gives out a portion of nitrous acid, and becomes converted into a red substance, similar in all respects to the red calx of mercury formed by simple heating it in contact with vital air. This is known by the name of red precipitate.

When red precipitate is strongly heated, a large quantity of vital air is disengaged, together with some phlogificated air, and the mercury is sublimed in the metallic form.

Mercurial nitre is more soluble in hot than cold water, and affords crystals by cooling. It is decomposed by the affusion of a large quantity of water, unless the acid be in excess.

When mercury is dissolved in nitrous acid by means of heat, nitrous air is emitted at first ; and afterwards it ceases, though the solution still proceeds. The mercury which is taken up during the first part of the process is calcined, and the other portion is dissolved in the metallic state. If the solution be stopped in the first part of the process, fixed and volatile pure alkalis precipitate the yellow calx ; but if the solution be continued after the escape of the elastic fluid has ceased, the precipitate obtained by the same means is black, on account of the admixture of metallic mercury, which may be separated from the yellow calx by distillation.

Ponderous earth, magnesia, and lime, precipitate the nitrous solutions of mercury ; and these precipitates, as well as all the other calces of this metal, are reducible by heat alone without addition.

The precipitates of mercury from acids, by means of alkalis, possess the property of exploding when exposed to a gradual heat in an iron spoon, after having been previously triturated with one-sixth of their weight of flowers of sulphur. The residue consists of a violet-coloured powder, which is converted by sublimation into cinnabar. It seems therefore as if the sulphur combined suddenly with the mercury, and expelled vital air in the elastic state.

The

The vitriolic acid, or the salts containing it, decompose the nitrous solutions of mercury by virtue of the stronger attraction of the vitriolic acid to the metal. The precipitate which falls down does not essentially differ from the substance produced by the direct solution of mercury in the vitriolic acid. The marine acid likewise seizes the mercury dissolved in the nitrous acid, and forms a compound which falls to the bottom. This consists of a very caustic salt, which is called corrosive sublimate, and is produced when the nitrous solution contains only calx of mercury; but when that solution is saturated with metallic mercury, the compound which falls down by the addition of marine acid is called white precipitate, and does not differ from the preparation which, when made in the dry way, is called calomel, or mercurius dulcis.

The acetous and most other acids combine with the calx of mercury, and precipitate it from its solution in the nitrous acid.

The marine acid does not act perceptibly upon mercury in the metallic state; but the dephlogisticated or aerated marine acid readily dissolves it, and forms the same combination as arises from the direct union of marine acid with calx of mercury; that is to say, corrosive sublimate.

The great specific gravity of mercury rendered it an object of peculiar attention to the alchemists and earlier chemists; many of whom hoped to fix it in the form of a solid substance, or to extract gold from it. From these motives, a great variety of processes have been made with it, by methods which are much less direct and simple than those of modern chemistry. Among others, the combination of the calx of mercury with marine acid is produced by several methods in the dry way by sublimation. In the large way, corrosive sublimate is prepared by triturating equal parts of mercury, common salt, and vitriol together, and exposing the whole to a moderate heat. The corrosive sublimate rises, and adheres to the upper part of the glass vessel. In this operation the vitriolic acid from the vitriol is supposed to calcine the mercury, or to dephlogisticate the marine acid of the common salt; in either of which cases the compound of marine acid with calx of mercury will be formed. From this theory, it will easily be understood that corrosive sublimate may be prepared by various methods. If the white mass or calx of mercury, produced by exposing that metal to the action of vitriolic acid, be heated in a matrass with an equal quantity of common salt, this sublimate will be had by double affinity; the vitriolic acid partly saturating the alkali, and the marine acid uniting with the calx of mercury, and rising by sublimation. In the same manner, the nitrous mercurial salt, or the mercurial precipitates, may be used instead of the calx of mercury by vitriolic acid.

As the causticity of metallic salts depends chiefly on the disposition of the calcined metal to resume the metallic state, at the same time that it burns or calcines the substance to which it may be applied; it is accordingly found that corrosive sublimate possesses this property in the most eminent degree; it is therefore one of the most active mineral poisons. This salt is soluble in water, though sparingly, and also in ardent spirit. It is precipitated of an orange colour by fixed alkalis. The absorbent earths likewise throw down its calx. Volatile alkali affords a white precipitate, which soon afterwards assumes a slate colour.

Corrosive sublimate becomes much more soluble in water by the addition of sal ammoniac, with which it forms a triple compound, called sal alembroth by the alchemists, which crystallizes by cooling. The addition of a fixed alkali throws down a white calx of mercury, called white precipitate in the dispensaries.

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The preparation of calomel is usually made by triturating corrosive sublimate in a glass mortar with fluid mercury, added by a little at a time, until no more can be made to disappear. A small quantity of water added to the corrosive sublimate during this part of the process, prevents that salt from rising in the form of noxious dust. In this state the combination is the same as that obtained from the saturated nitrous solution of mercury by the addition of marine acid. The mixture of corrosive sublimate and mercury is more perfectly combined by exposing it to sublimation. It adheres to the internal part of the subliming vessel, in the form of a white mass of a striated texture. If there be any suspicion of its containing corrosive sublimate, which is not probable on account of the more volatile nature of the latter, they may be separated by means of warm water, the calomel being insoluble.

When one part of antimony, which is the native combination or ore of antimony with sulphur, is triturated or accurately mixed with two parts of corrosive sublimate, and exposed to distillation, the dephlogisticated or aerated marine acid combines with the regulus of antimony, and rises in the form of the compound called butter of antimony; while the sulphur combines with the mercury, and forms cinnabar. If the regulus of antimony be used instead of the mineral, the residue which rises last consists of running mercury, instead of cinnabar.

Mercury combines very readily with sulphur. By trituration in a mortar the mercury disappears, and forms a black compound with the sulphur, which is called ethiops mineral, or mercurial ethiops. The combination is more speedily made by mixing fluid mercury with melted sulphur. In this way three parts of flowers of sulphur unite with one of mercury. If the sulphur be set on fire, the greatest part burns, and the remainder is of a violet colour when pulverized. This consists of a more intimate combination of mercury and sulphur. It rises in a heat nearly approaching to redness; and the sublimate, which is called cinnabar, contains about one fifth part sulphur, and the rest mercury. The pigment called vermilion consists of artificial cinnabar reduced to a powder. See CINNABAR.

Livers of sulphur are decomposed in the humid way by mercury, which unites with sulphur. With the fixed alkaline livers of sulphur it forms a black powder, or ethiops, by agitation, which in the course of a number of years becomes red; but the volatile alkaline hepar, or fuming liquor of Boyle, converts mercury into a fine cinnabar in a very short time. Turbith mineral, and the precipitates of mercury, are likewise converted into cinnabar by this alkaline hepar.

Mercury unites by trituration with oils and mucilages, with which it forms black or deep blue compounds. A small part of the mercury in these seems to be in combination, and the rest in a state of extreme division.

This metal can scarcely be exhibited in the dry way, on account of its volatility. The degree of heat required to convert it into the red calx called precipitate *per se*, is rather lower than its boiling point, and a greater reduces it again to the metallic state. The calcination and reduction of mercury, without addition, afford one of the strongest arguments in favour of the system which rejects phlogiston.

In the production of the red calx of mercury, it is required that air be present, and the metal kept in a state of brisk evaporation. On this account it is found convenient that the vessel should be so deep, and its aperture so small, that the fumes may not make their escape. It may be inferred, that in this as well as other calcinations there is an absorption of vital air; more especially as vital air is expelled

expelled from the calx by heat *. When the experiment is made in closed vessels by means of a body whose neck is introduced beneath a jar containing common air over mercury, the vital part is absorbed, and phlogificated or foul air remains; and afterwards, by an augmentation of heat, the mercury is revived, at the same time that it restores the constitution of the air by the emission of the vital air. Ten days or a fortnight's constant heat is required to convert a few grains of mercury into precipitate *per se* in the small way.

Mercury being habitually fluid, very readily combines with most of the metals, to which it communicates more or less of its fusibility. When these metallic mixtures contain a sufficient quantity of mercury to render them soft at a mean temperature, they are called amalgams.

It very readily combines with gold, silver, lead, tin, bismuth, and zinc; more difficultly with copper, arsenic, and regulus of antimony; and scarcely at all with platina or iron: it does not unite with nickel or cobalt; and its action on manganese, wolfram, and molybdena, is not known. Looking-glasses are covered on the back surface with an amalgam of tin. In this operation, mercury is poured on tin foil, upon a flat stone, and spread with a feather, till its union with the tin has brightened every part of its surface. A large quantity of mercury is then poured on, and the glass is slid along the fluid surface; upon which it is afterwards pressed by weights, to exclude the superfluous mercury.

Mercury is found native in slaty or quartzose earths, or visibly diffused through masses of clay or stone. Native precipitate *per se*, or calx of mercury, has also been found; and this metal has likewise been met with in combination with the vitriolic and marine acids. Its volatility may probably have caused it to be overlooked in many minerals that may contain it. The greatest quantity of mercury is found in combination with sulphur, in the form of cinnabar. Mercury is a scarce metal. Most of the mercury in commerce is afforded by the mines of Idria in the Austrian dominions, Almaden in Spain, and Guancavelica in Peru. The native mercury requires little more than washing to separate it from its matrix. Cinnabar in the native state is frequently mixed with calcareous earth; in which case the mercury may be separated by distillation, because the calcareous earth combines with and detains the sulphur. Pure cinnabar may be decomposed by the addition of about one third of its weight of iron. In all cases wherein pure mercury is required, it must be distilled from cinnabar, or its sulphureous combination. For this purpose, the mercury may be converted into ethiops, and distilled with twice its weight of quicklime or iron filings. Mercury in commerce is judged to be pure when it is perfectly fluid, and runs in neat globules, without any pellicle on its surface, or without soiling a funnel of clean white paper, through which it may be poured by a very small aperture at bottom. If it leaves nothing behind after evaporation, its purity may be still more depended on.

To analyse native cinnabar, its stony matrix should first be dissolved in nitrous acid; and the cinnabar, being disengaged, should be boiled in eight or ten times its weight of aqua regia, composed of three parts nitrous, and one marine acid: the mercury may then be precipitated in the metallic form by the addition of zinc.

The uses of mercury have already been mentioned in the present article, and

* Lavoisier, *Traité Elementaire de Chimie*, page 35.

elsewhere. The amalgamation of the noble metals, water-gilding, the making of vermilion, the silvering of looking-glasses, and the preparation of several powerful medicines, are the principal uses to which this metal is applied.

MERCURY OF THE PHILOSOPHERS; and

MERCURIFICATION. I take these articles without alteration from the dictionary of Macquer, as the subject does not seem to require, or deserve, any very extensive research. Alchemists have given the name of mercury to many other things besides the metallic substance generally so called. This latter they call ordinary mercury, and value it little. We cannot precisely say what they meant by their mercury, from the obscurity of their writings, and also from their different descriptions of the matter. No term is more frequently used by them than this. In every page of their writings we find the words mercury, mercurification, &c. Probably they had not all the same idea annexed to the term philosophical mercury. The most probable opinion upon this subject is, that this mercury is the metallic principle which Becher has called mercurial earth. See **EARTH MERCURIAL**.

Mercurification is an alchemical operation, by which metals are said to be reduced into a fluid, heavy, opaque, and shining liquor, like ordinary mercury; or by which the mercurial principle may be extracted from metals, and obtained in the form of quicksilver. But these mercurified metals, or their mercurial principle rendered sensible, are a kind of philosophical mercury, which, although they resemble ordinary mercury, are nevertheless said, by persons exercised in such studies, to differ from it considerably, by having a greater specific gravity, by more effectually penetrating and dissolving metals, by a stronger adhesion to these, and by a less volatility.

We may find in the books of many authors, who, though not alchemists, give more or less attention to these subjects, a great number of processes for mercurification, or for obtaining mercury of metals; most of which are very long, laborious, confused, and consequently subject to fail. The detail of these processes would be too long. An account of the principal of these operations may be seen in Junker's *Conspectus Chimiæ*. We shall only mention some of the easiest mercurifications extracted from the most modern authors, as Wallerius and Teichmeyer.

If cinnabar of antimony made with corrosive sublimate be distilled, we shall obtain, by reviving the mercury, a larger quantity of mercury than was originally in the corrosive sublimate.

If a corrosive sublimate be prepared with spirit of salt and fluid mercury, and if calx or filings of silver be several times sublimed together with this corrosive sublimate, a part of the silver will be changed into mercury.

Very fine filings of iron, exposed during a year to the air, and afterwards well triturated in a mortar, and cleansed from dust and extraneous matter, then exposed during another year to the air, and lastly, distilled in a retort, furnish a hard matter which attaches itself to the neck of the retort, and with this matter a little mercury. **TEICHMEYER.**

If calx of copper be mixed with sal ammoniac, and this mixture exposed during a certain time to air, and distilled with soap, mercury will be obtained.

If luna cornea or plumbum corneum be mixed with an equal weight of very concentrated spirit of salt, digested together during three or four weeks, then an equal quantity of black flux and Venice soap added to it, and the whole matter distilled in a glass retort, some mercury will pass into the receiver.

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These experiments are important, and easily made, but have not been repeated by modern chemists; for which we see no other reason than the small hopes of their succeeding. If they should succeed, they would ascertain the existence of a mercurial principal in metals, and would so much more confirm the theory of Becher, as all the experiments above mentioned are made with the marine acid, which that chemist supposes to contain the mercurial earth. The conclusion deducible from these experiments would be, that, by introducing a superabundant quantity of mercurial earth into metals, a true mercury might be obtained from them. See METALS.

Many other processes for mercurification may be seen in authors who have treated of this matter, particularly in Junker's book above quoted, in which marine acid is not employed, but other saline matters, or sublimation through the burning fuel, with concurrence of free air, in Geber's manner. In this latter case, we must look for the mercurial substance in the metallic fumes and flowers; and if any such substance be obtained, it must evidently proceed from the decomposition of the metallic matter employed.

Mr. Groffe says, in the Memoirs of the Academy, that he obtained mercury from lead by an easier and simpler process than those above mentioned. This consists in saturating perfectly some good nitrous acid with lead, which may be done effectually by employing more lead than the acid can dissolve; and from this solution, according to Mr. Groffe, a gray powder is precipitated, in which mercury is discovered. This experiment being short, Messrs. Macquer and Beaumé repeated it with due attention in their Course of Chemistry; but they did not find the gray mercurial powder mentioned by Mr. Groffe. As the exactness and veracity of that able chemist are well known, we must believe that the lead which he employed contained some extraneous mercury, which might easily happen in a laboratory. The same thing has possibly happened in other experiments of mercurification; and this proves how circumspect we ought to be in drawing conclusions.

METALS. Metallic substances are very easily distinguishable from all other bodies in nature, by their very great weight, and that opaque shining appearance which is called the metallic splendour or brilliancy. Very few substances have half the specific gravity of the lightest among the metals. They are all fusible, though at very different temperatures; and if the fusion be made in close vessels, they fix again by cold, without having suffered any change but that of external figure, which must be produced in all bodies which have been either liquefied or volatilized; namely, they assume the form of the vessel which contains them. Some of them may be extended considerably by the hammer, without breaking them. This property is called malleability; and the metallic bodies which possess it are called entire metals, or metals, in contra-distinction to such as are more brittle, and are called semi-metals. Metallic substances are also called perfect and imperfect. The perfect are such as undergo no lasting change of their properties by any heat we can apply to them, at least, in common furnaces. The imperfect metals, when exposed to a strong heat, with access of vital air, are changed, by a process similar to burning, and in some of them with an actual flame, into a brittle dull substance, called a calx, which is heavier than the metal it came from, though its specific gravity is not so great. Some are even converted into acids. If the calx of a metal be exposed to strong heat in a closed vessel, with some inflammable matter, it recovers its metallic state. This is called reduction, or reviving of the metal.

All metals are imperfect, except gold, silver, and platina. The imperfect metals are, mercury, lead, copper, iron, and tin; and the semi-metals are, bismuth, nickel, arsenic, cobalt, zinc, antimony, manganese, wolfram, molybdena, and uranite. The names arsenic, antimony, manganese, wolfram, and molybdena, being used to denote the mineral substance from which the semi-metals are obtained, the semi-metals themselves are distinguished by the name of regulus of arsenic, regulus of antimony, and so forth; though modern chemists often use the simple term to denote the semi-metal itself alone.

Metals, like other fusible bodies, have each a fixed temperature, or freezing point, at which they become solid. They assume a crystallized figure in cooling, which is different in each, and may be seen by fusing them in melting pots with a hole in the bottom stopped with a stopper; or better in many cases, by a dish or flat mould, and tilting it; for, in this case, if the surface be suffered to congeal, and the fluid metal beneath be suffered to run out through the hole, the under surface of the remaining metal will be curiously crystallized. The specific gravity of metallic substances is very considerably affected by the gradual or hasty cooling, or transition from the fluid to the solid state. Hammering renders them harder and more elastic; but this effect is destroyed by ignition.

The affinities of metals to each other are various. Some will not unite at all; others mix very readily, and even combine together. On this property is founded the art of soldering; which consists in joining two pieces of metal together by heating them, with a thin piece or plate of a more fusible metal interposed between them. Thus tin is a solder for lead; brass, gold, or silver, are solders for iron, &c.

Mountainous districts, where the surface of the globe has been thrown up or disturbed, in remote ages, by earthquakes, volcanos, or other great convulsions of nature, are the most abundant in metallic bodies. In digging into the bowels of the earth, the various metals are mostly found disposed in strata or beds, which in plains lie level, but in mountains are inclined; whence it happens, that in mountainous countries some strata are often exposed to the day, which would else have been too deeply lodged to be come at by human art. It is in the stratified mountains that metals are usually found, mostly in a state of combination either with sulphur or arsenic, or in the state of a calx. They are also found, though less frequently, in the metallic or native state.

The combinations, or earthy bodies which contain metals in sufficient quantity to be worth extracting, are called ores. Iron ore sometimes forms entire mountains; but in general the metallic part of a mountain is very inconsiderable in proportion to the whole. The ores run either parallel to the stony strata, though far from having the same regularity of thickness, or they cross the strata in all directions. These metallic strata are called veins. The cavity formed by art in the earth, for the extraction of metals or any other mineral bodies, is called a mine. The stone wherein a metallic ore is usually bedded, is called its matrix. These are not peculiarly appropriated to any metal, though some stones more frequently accompany metals than others.

The general operations by which metals are obtained from ores are—1. The minerals are selected; and such only are taken as from experience are known, by the external figure or appearance, to contain metal. 2. They are reduced to powder; and the lighter parts washed away, by means of water, in a shallow trough. 3. The volatile parts are dissipated by the operation called roasting. 4. The ores are smelted by throwing them into the midst of the fuel of a furnace, with

with earthy substances which are disposed to run into glafs. In this operation, the glassy matter, called scoria, in some measure produces the effect of rendering the lower part of the furnace a closed vessel; and the fuel revives the metal, which in the ore is usually of the nature of calx. The revived metal being much denser than the scoria, falls to the bottom, and is suffered to run out by proper openings. These are the general operations, but they are not all necessary in all cases; and the particular practice with the several ores of each metal, must vary according to the properties of the metal itself, and the different substances it is united with.

The extraction of metals from ores, in the small way, which is necessary to be made in order to ascertain whether the specimens are worth working, is called assaying or essaying. In these small trials, the fusibility of the pounded ore is increased by an addition of black flux, which is an impure alkali, formed by mixing two parts of tartar with one of nitre, and setting them on fire. Metallic ores may be very accurately assayed by solution and precipitation in the humid way. See the several METALS.

The theory of the calcination and reduction of metals, according to the system of phlogiston, is as follows:—Metals, like all other inflammable bodies, contain phlogiston united to a base. While the vital part of the air unites with the base, the phlogiston is disengaged, and leaves behind it the combination called a calx, which is heavier than the metal, because the air received exceeds the weight of the phlogiston disengaged.—In the antiphlogistic system, metals are considered as simple substances, which are converted into calces by their union with vital air, and are revived by heating them with any other matter which is more combustible than themselves; that is to say, which has a stronger attraction for vital air, at the temperature of reduction. Some of the maintainers of phlogiston admit that the vital air unites with that principle of inflammability, and composes a substance which combines with the base of the metal. Here the fact agrees with the statement of the antiphlogistians, but the explanation is less simple.

Most metals will uniformly mix with each other; and the specific gravity of the compound is seldom such, as would have been deduced from the supposition of a mere mixture, or simple opposition of parts. Their fusibility is likewise greatly changed by mixture, and according to no certain rule yet discovered.

Mixtures of metals are frequently called alloys. But the word alloy, or allay, is mostly used to denote a portion of metal which is added to the precious metals, gold or silver.

Metals are mostly soluble in acids, with which they form salts. When a metal is added to an acid, the general effect produced is the same as would have arisen from the addition of any other combustible substance to the acid. If an alkali or earth be added to a metallic solution, the metal falls to the bottom in the form of a calx. But if a metal which has a stronger affinity with the acid than the metal already dissolved has, be added to such a solution, the former metal will fall to the bottom in its metallic state, and the latter will be dissolved without causing any of the escape of elastic fluid, and other appearances, which would have taken place if it had been applied to the mere acid; notwithstanding which, the latter metal, if precipitated by an incombustible substance, such as an alkali or earth, will be in the state of a calx.

It is evident, from these facts, that the action of acids upon metals is similar to that of heat with access of vital air; and of course may be accounted for, upon both the theories of chemistry, in the same manner as combustion itself. Accord-

ing to the original theory, when an acid acts upon a metal, it unites with the base of the metal, and expels the phlogiston; which either rises alone, in the form of inflammable air; or, combining with the acid itself, forms an acid air, or volatile acid. If an alkali be added, the calx falls down, combined with air, which it obtains either from the alkali or the acid; but if a metal be added, the phlogiston of this last, uniting with the calx of the former, revives it, and it falls down in its metallic state. The new theory may be applied as follows: When a metal is added to an acid, it attracts vital air either from the acid itself or from the water. If the former, the acid itself is decomposed, and its base, combined with an under proportion of vital air, arises in the form of volatile acid, or acid air. But, if the latter, the water itself is decomposed, its vital air combining with the metal, and its inflammable air flying off: in this case, the acid is supposed to do nothing more than hold the calx in solution, and by that means facilitate the action of the water, which would be much less effectual if the calx were suffered, on account of its insolubility, to remain upon and defend the surface of the metal; which by reason of its insolubility as mere water, it would not fail to do, if the acid were not present.

Metals are precipitated by each other in the same order, or nearly so, in all acids. Hence it is inferred, that this effect is produced by the re-action of some common principle, either of the metal or of the acids. In the old theory, a metal which has a stronger attraction for phlogiston, will take that principle from another metal which holds it more weakly; and of course the latter will cause the former to be precipitated in its metallic form. In the new theory, a contrary transposition of vital air from the acid produces the same effect: for, if a metal has a stronger attraction for vital air than is exerted by another metal already in solution, it will deprive this last of it, and cause it to fall down in the metallic state.

Acids dissolve metals only in their calciform state; and there is a certain limit near which the solution is best performed. If an acid be of such a nature as to be incapable of calcining a metal, it will not dissolve it, though the same acid would dissolve the calx if presented to it; and if the calcination be carried on too far, the calx will likewise be insoluble. To explain this according to the two theories, it may be observed, that acids calcine metals by virtue of their attraction for phlogiston, and suspend the calx by virtue of the same power exerted on the remaining portion of phlogiston, of which they cannot in general divest the calx; consequently, if the calx be divested of this portion, it will be insoluble. Or, in the other theory, the simple metal attracts as much vital air from the acid as is sufficient to convert itself into a calx, but not enough to saturate it with that principle: it is therefore suspended, in consequence of its remaining weak attraction for the vital air of the acid. But if the calcination be complete, that is to say, if the affinity of the metal for vital air be perfectly satisfied, the remaining attraction of the metal for vital air will cease, and it will be insoluble.

The direct action of alkaline salts upon metals is not considerable: sulphur combines with most of them readily in the way of fusion; and the combination of sulphur with an alkali, called liver of sulphur, is a powerful solvent of all metals except zinc. Nitre heated with metals acts in the same manner as it does with other inflammable bodies: it deslagrates, and the metals become calcined. The perfect metals resist the action of nitre.

METALLURGY. The characters from which mineralogists pretend to assert the existence of an ore in the bowels of the earth, are all equivocal and suspicious. The savage aspect of a mountain, the nature of the plants which grow

grow upon it, the exhalations which arise from the earth, all afford characters too doubtful for a reasonable man to risk his fortune upon such indications alone.—The dipping wand, or divining rod, is the fruit of superstition and ignorance: and the ridicule which has been successively thrown upon this class of impostors, has diminished their number; at the same time that the numerous dupes of this class of men have rendered their successors more prudent. It is nevertheless used in Cornwall to this day.

The nature of the stones which compose a mountain is capable of furnishing some indications. We know, for example, that ores are seldom found in granite, and the other primitive mountains; we know likewise that mountains of too modern a formation contain them very rarely; and we find them only in secondary mountains, in which the schistus and ancient calcareous stone are void of all impressions of shells.

The presence of ponderous spar, forming a stratum or vein at the surface of the earth, has been considered by many mineralogists as a very good indication. Chaptal shews very good reason for believing that this stone is the same which Becher has spoken of in his works, under the name of Vitriifiable Earth, which he considered as a principle of metals; and that it has been very improperly taken for quartz by his readers.

When we possess indications of the existence of an ore in any place, we may use the borer, to confirm or destroy these suspicions, at a small expence.

It frequently happens that the veins are naked or uncovered: the mixture of stones and metals forms a kind of cement, which resists the destructive action of time longer than the rest of the mountain; and as these parts of rocks, connected by a metallic cement, present a stronger resistance to the action of waters, which incessantly corrode and diminish mountains, and carry away their parts into the sea, we frequently observe the veins projecting on the sides of mountains incruusted with some slight metallic impression, altered by the lapse of time.

The nature of an ore is judged from inspection. A slight acquaintance with this subject is sufficient to enable the observer to form an immediate judgment of the nature of an ore. The blow-pipe is an instrument by the assistance of which we may in a short time become acquainted likewise with the species of the ore. See BLOW-PIPE. This knowledge forms the docimastic art, or docimasia. In order to make the assay of an ore, in general, for all ores do not require the same processes, small pieces of the mineral are examined. These are cleared from foreign and stony substances as much as possible. The pure mineral is then pounded, and a certain quantity weighed, which is torified in a vessel larger and less deep than a common crucible. By this means the sulphur, or the arsenic in combination with the metal, is dissipated; and by the loss of weight resulting from the calcination, a judgment is formed of the proportion of foreign volatile matter it contained.

This first operation shews the proportion and quantity of sulphur and arsenic which may be mixed with the metal. The sulphureous smell may easily be distinguished from the smell of garlic, which characterizes arsenic. These foreign substances mixed with the metal are called mineralizers.

In order to obtain an accurate judgment of the weight of the mineralizer, the augmentation in weight which the metal has undergone in passing from its metallic state to that of oxide or calx, must be added to the loss occasioned by the calcination.

Two hundred grains of this roasted ore are then to be taken, and mixed with
fluxes

fluxes capable of fusing and reducing it. In this operation a crucible is made use of; and a sufficient degree of heat being applied, the metal is precipitated to the bottom of the crucible in a button, whose weight indicates the quantity of metal contained in the ore.

These fluxes must be varied according to the nature of the ores under examination. It is necessary that they should all contain the coaly principle, to disengage the vital air with which these metals are impregnated by the calcination. But the nature of the flux must be varied according to the fusibility of the metal. The three following will answer all these purposes:

1. The fusible material called black flux is made with two parts of tartar, and one part of nitre, melted together. The coaly and alkaline residue is used to reduce the ores of lead, copper, antimony, &c.

2. Two hundred grains of calcined borax, one hundred grains of nitre, twenty grains of flaked lime, and one hundred grains of the ore intended to be assayed, form the flux of Scopoli, which Chaptal found advantageous in the assay of iron ores.

The vitreous flux of M. de Morveau, made with eight parts of pounded glass, one of borax, and half a part of powder of charcoal, may be employed for the same purpose.

3. Arsenic and nitre, in equal parts, form likewise a very active flux.

The neutral arsenical salt has been used with success to fuse platina.

As soon as the existence of a mine, and its nature and riches are ascertained, it is in the next place necessary to be assured of a sufficient abundance and continuity of water to answer the purposes of the works. It is likewise necessary to be assured of possessing a sufficient quantity of wood or charcoal, and more especially, a good director must be procured: for a poor mine well managed is preferable to a rich one ill conducted.

These preliminary circumstances being accomplished, the most simple and least expensive processes must be employed in extracting the mineral from the bowels of the earth. For this purpose, shafts or galleries must be dug, according to the position of the vein, and the nature of its situation.

When it is practicable to arrive at the side of the vein, and at a certain depth, by a horizontal gallery, the works become more simple and economical; the same opening serving to draw off the waters, and extract the ore. Galleries are then to be carried on to the right and left; and shafts sunk, which communicate with the open air, as likewise others carried down into the vein. Galleries are likewise constructed, one above the other, and the communication of the works kept up by ladders. When the soil is friable, and defective in solidity, care must be taken to support it with timbers of sufficient strength, to prevent its falling in.

Pickaxes, wedges, and levers are used to detach the ore, when the rock is soft; but it is most commonly necessary to employ gunpowder.

Want of air, and the abundance of water, are almost always noxious, and derange mine-works. The water is carried off by fire-engines, wind-mill pumps, and other suitable apparatus.

Currents of air are produced by establishing communications with the galleries, by horizontal apertures. Furnaces erected on the side of a shaft, to which a long tube is adapted at one end, communicating with the ash-hole, and at the other plunging into the shaft to draw up the air, or ventilators placed in the same situation answer a similar purpose. The foul air is destroyed by rendering a lixivium of ashes caustic; and sprinkling quick lime about the mine likewise produces the same effect.

A prudent company ought to extract the largest possible quantity of ore, before they determine upon constructing the necessary works for the subsequent processes. We cannot see into the bowels of the earth. Appearances are often deceitful; and we have seen companies either ruined or discouraged, because they had employed immense sums to construct the necessary furnaces to work an ore whose existence was doubtful. When the proceedings, in an undertaking of this kind, are carried on with proper precaution, and no more expence is entered into than what the ore extracted, and of a known value, is capable of representing, the probable losses are very slight, even in the poorest mine.

The works ought to be varied according to the nature and state of the mineral. It is found in three states:—1. In the form of a native metal: in this case, nothing more is necessary than to extract it out of the mine, to clear it of the extraneous substances, and to fuse it. 2. In the form of calx: and in this state it is sufficient if it be sorted and fused. 3. Combined with sulphur or arsenic, in which case it must be made to undergo some other operations.

Although, in this last case, the works, subsequent to the extraction, vary according to the nature of the ore, there are nevertheless certain general operations to which every kind of ore is subjected.

The first business must be to clear the metal of the stony matter or matrix. For this purpose, when the ore is extracted, children are employed who examine it, and separate the pure ore, or rich mineral, from that which is mixed with the gangue. As in this second quality the stone is mixed with the ore, the whole is pulverized by means of a stamping mill, consisting of pestles of wood, shod with iron, and armed with cocks, which are raised by levers proceeding from the axis of a wheel that constantly turns. The mineral is by this means crushed and pulverized; and a stream of water, which is made to pass over it, carries away both the metallic and stony particles; the former being deposited in the first vessels through which the water is made to circulate, while the latter, or stony part, is carried to a greater distance, on account of its lightness.

This pulverized ore is called *schlich*; and in order to separate all the earthy parts, it is washed upon tables slightly inclined, over which a constant stream of water is made to flow. The *schlich* is agitated with brooms; the water carries away all the fragments of stone, and leaves the pure ore upon the table.

The calcination of the mineral succeeds the washing. In this operation, the mineralizer is carried off. Fire is always the agent made use of. Sometimes the pounded mineral is disposed in piles upon heaps of wood, which being set on fire, heat the ore strongly, and drive off the mineralizer. This calcination possesses the double advantage of disposing the metal for fusion, as well as clearing it of the mineralizing substance. When the ore is more friable, it is spread out in a reverberatory furnace; and the flame which reverberates upon it deprives it of its mineralizer, at the same time that it partly fuses it.

M. Exchaquet has proposed to destroy the sulphur by nitre in assays. This process is excellent for copper ores: the quantity of nitre varies according to the quantity of sulphur; but there is no danger of adding too much. In this operation the mixture is thrown into an ignited crucible, and kept at a moderate heat for some minutes.

The fusion is effected in furnaces, excited by a current of air, kept up by means of large bellows, or a machine called a *trompe*. See *TROMPE*.

METEORS, and

METEOROLOGY. The state and condition of the great fluid mass, in which we breathe, and the changes which take place therein, are objects of no

small importance to the chemical philosopher. Among the variety of experiments on permanently elastic fluids, it is found that most of them are capable of uniformly mixing together, when their nature is such as not to act perceptibly upon each other. But in the extensive mass of the atmosphere, it seems likely that considerable separations of its component parts take place in consequence of their different specific gravities. This supposition is countenanced by several optical phenomena, such as the double appearance of head lands. In this way some writers account for the appearance of the aurora-borealis, shooting stars, and other similar appearances, which they suppose to consist of inflammable air, occupying the upper region of the atmosphere, and fired by electricity. It is a remarkable circumstance, that most of these fiery appearances happen at an elevation, which is geometrically determined to be almost twice as great as that which astronomical writers, by deductions founded on the refraction of the light of the heavenly bodies, and the law of dilatation of air near the surface of the earth, have assigned as the sensible limit of the atmosphere. Hence it should follow, that the elasticity of the upper parts exceeds that of the lower; which affords no inconsiderable presumption that this upper part is chiefly composed of such air as we know to be the most elastic, namely, the inflammable. The composition of water out of the two ingredients, vital and inflammable air, has also afforded ground for meteorological induction. It has been concluded, that water is not only condensed and precipitated by the agency of electricity, in thunder storms, but that it is likewise composed out of its elements by the combustion of these two airs in every case where atmospherical corrosion is exhibited.

The phenomena of winds, though chiefly depending on the hydrostatical change in the density of the air by alteration of temperature, well deserve the attention of the chemist. The effect of furnaces, the clearing of laboratories, burial vaults, houses of office, mines, and other excavations, from noxious effluvia, are all governed by general laws of the same nature as those which cause the currents of air around us. Even the sudden and frequently impetuous current of air which accompanies a fall of rain, or squall, though it be merely produced by the mechanical action of the falling drops of water, has afforded ground for useful meditation. There is no doubt but we are indebted to considerations on this natural appearance for the cheap and useful blowing-machine, which the French call a *trompe*. See *TROMPE*.

It may seem at the first sight, as if observations on the standing of the barometer and thermometer were of no very immediate use to the practical chemist. But if it be considered, that the effect of an air furnace depends on the difference of the density of the air in the chimney, and that which enters the ash-hole; and that the mere difference indicated by the barometer, amounts to one fifteenth part in its extremes of the whole quantity of the external air, in a given place, not to mention the effect pointed out by the thermometer, it will not appear strange that these causes should greatly influence the results in metallurgical operations, and be very perceptible in the burning of our culinary fires. The philosophical chemist is no less interested in the state of the air, as shewn by these instruments. For it cannot but be of great consequence to his deductions, to know the external pressure which is constantly acting upon the elastic fluids he may either weigh or measure. If this and the temperature be not carefully attended to, he will scarcely find any two results, made at distant times, agree.

The presence of moisture, or rather its disposition to be absorbed, or given out, as shewn by the hygrometer, must be of considerable importance. It affects the elasticity of every kind of air, and there is no doubt but combustion and its products

ducts will vary accordingly as it is maintained by an air which is moister or more dry. It is probable that the quantities of finery cinder afforded by iron may vary from this cause.

The effects of solution and precipitation analogous to what happens in denser fluids, have been, perhaps too fancifully, delineated among the atmospheric changes. But there is every reason to think, that as our knowledge of the great system of nature shall improve, the play of the chemical affinities will shew itself more evidently in the atmosphere.

METHEGLIN. A fermented beverage made from honey.

MICA. This stone in its purest state is colourless; but either from a less intimate combination, or from a mixture of some superfluous ingredient, principally iron, it is found of different colours, white, red, yellow, green, brown, or black (the white and yellow sort have a splendid metallic appearance), smooth, but not greasy to the touch, which distinguishes it from talc. Its texture is always lamellar or scaly, and the lamellæ, or scales, are slightly flexible and often elastic; these scales are sometimes parallel to each other, sometimes interwoven, sometimes wavy or undulated, and sometimes they represent filaments. Its specific gravity is from 2.535 to 3.000, when loaded with iron.

It does not effervesce with acids, and is insoluble in them without particular management; but after it has been calcined with four times its weight of fixed alkali, it effervesces strongly, and is in great measure soluble.

The pure colourless mica is infusible *per se*, and scarcely melts even with mineral alkali, but yields more readily to borax or microcosmic salt, with scarce any effervescence; but the coloured sorts were found by M. Saussure to be fusible *per se*, though with difficulty, for they require a stronger heat than shoerl does.

One hundred parts of the colourless kind contain 38 of silicx, 28 of argill, 20 of magnesia, and 14 of the most dephlogisticated calx of iron. Martial mica contains besides, 10 or 12 per cent. of a more phlogisticated calx of iron, from whence its various colours are derived, and a proportionably smaller quantity of the other ingredients.

MICROCOSMIC SALT. A triple salt obtained from urine, and much used in assays by the blow-pipe, under this name. The method of extracting it according to Weigleb is as follows:—A large quantity of urine, either fresh or putrid, is evaporated to the consistence of a thin syrup. The vessel is then set by in a cool place, and in the space of a month the microcosmic salt separates in the form of prismatic crystals, of a slightly saline taste and reddish brown colour. The remaining liquor being decanted, these crystals are again dissolved in as much warm water as is requisite, and the filtered liquor is immediately set in a cooler place, whence in the space of five days finer and purer crystals are obtained. These may afterwards be dissolved once more in warm water, filtered and crystallized till they have acquired the requisite whiteness. The quantity thus obtained is very small. As the phosphoric acid is now easily to be procured or made, it would probably answer the purpose of the chemical philosopher better, to use the pure combination of phosphoric acid, and volatile alkali made in the direct way. This salt does not crystallize unless there be a slight excess of alkali.

MILD ALKALIS, or EARTHS. The alkalis and lime are usually met with in combination with fixed air. Heat expels this substance from lime, and the alkalis are deprived of it by the superior attraction of pure quick lime, with which they are treated for that purpose. These practical operations were made long before the existence and properties of fixed air were well ascertained. The

alkalis and lime, when combined with fixed air, obtained the name of mild, from their slight action upon organized substances, compared with their action when deprived of it. In this last state, they were said to be caustic. The terms caustic and mild are still frequently applied to the alkalis, and also to lime, magnesia, and ponderous earth.

MILK is a well known fluid, secreted in peculiar vessels of the females of the human species, of quadrupeds, and of cetaceous animals, and destined for the purpose of nourishing their young. Its appearance and component parts are not altogether the same in various species of animals; but the differences have not yet been well ascertained. For this reason, in treating of milk, our attention will be confined to that of the cow, because the most abundantly met with. This fluid is of a beautiful opaque white colour, nearly as limpid as water, and of a pleasant emulsive taste. Its appearance on the stage of a microscope exhibits an infinity of minute opaque globules floating in a transparent fluid.

Cow's milk, distilled on a water bath, affords a tasteless phlegm of a faint smell, which is capable of putrefying. A stronger heat coagulates it. It is sometimes gradually dried into a substance which is a kind of saccharine extract, and may again be diffused in water. By destructive distillation, milk affords an acid, a fluid oil, a concrete oil, and volatile alkali. Its residual coal contains a small quantity of vegetable alkali, some salt of Sylvius, and phosphoric calcareous salt.

When milk is left to spontaneous decomposition, at a due temperature, it is found to be capable of passing through the vinous, acetous, and putrefactive fermentations. It appears however, probably on account of the small quantity of ardent spirit it contains, that the vinous fermentation lasts a very short time, and can scarcely be made to take place in every part of the fluid at once by the addition of any ferment. This seems to be the reason why the Tartars, who make a fermented wine from mare's milk, called koumiss, succeed by using large quantities at a time, and agitating it very frequently.

The coagulation of milk, in the manufacture of cheese, is effected by the addition of rennet, which is the infusion of the stomach of a sucking calf in water, prepared in various ways, according to the fancy of the makers. This fluid seems to owe its properties to the gastric juice of the animal. The separated curd is wrapped in a cloth with salt, and pressed, to deprive it of the superfluous whey; after which, it is preserved for several months or years before it is considered as fit for use.

Cheese, when decomposed by destructive distillation, affords an alkaline phlegm, an heavy oil, and much volatile alkali. Its residual coal is difficult to incinerate, and does not afford fixed alkali. By treating it with the nitrous acid, it is found to contain lime and phosphoric acid. Cheese is not soluble in water. Hot water hardens it.

The saccharine substance upon which the fermenting property of milk depends, is held in solution by the whey which remains after the separation of the curd in making cheese. This is separated by evaporation in the large way, for pharmaceutical purposes, in various parts of Switzerland. When the whey has been evaporated by heat, to the consistence of honey, it is poured into proper moulds, and exposed to dry in the sun. If this crude sugar of milk be dissolved in water, clarified with whites of eggs, and evaporated to the consistence of syrup, white crystals, in the form of rhomboidal parallelopipeds, are obtained.

Sugar of milk has a faint saccharine taste, and is soluble in three or four parts
of

of water. It yields by distillation the very same products that other sugars do. It is remarkable, however, that the empyreumatic oil has a smell resembling flowers of benzoin. Twelve ounces of diluted nitrous acid being poured upon four ounces of finely powdered sugar of milk, in a glass retort, on a sand-bath, with a receiver annexed, the mixture became gradually hot, and at length effervesced violently, and continued to do so for a considerable time after the retort was taken from the fire. It is necessary therefore, in making the experiment, to use a large retort, and not to lute the receiver too tight to the retort. After the effervescence had in some measure subsided, the retort was again placed on the sand-bath, and the nitrous acid distilled off, till the mass acquired a yellowish colour. This yellow fluid exhibited no crystals. Eight ounces more of the same nitrous acid were therefore added, and the distillation again repeated, till the yellow colour of the fluid disappeared. The fluid became inspissated by cooling; it was therefore re-dissolved in eight ounces of water, and filtered. Seven drams and a half of a white powder remained on the filter, and the clear solution afforded crystals of saccharine acid. The mother water was again treated several times with nitrous acid, by which means the whole was at length changed into saccharine acid.

The white powder that remained on the filter was found to be combustible, like oil in a red hot crucible, without leaving any mark of ashes behind. It was soluble in sixty times its weight of boiling water; and one fourth part separated by cooling, in the form of very small crystals. The remaining mass being then collected, by evaporating the greatest part of the water, left behind a small portion of the acid of sugar, of which it had not been so exactly deprived by edulcoration on the filter. From these circumstances it appeared, that the white matter was a salt; and, upon examination, it was found to be an acid possessing the following properties:

With all the soluble earths, it forms salts insoluble in water. It disengages fixed air from the mild alkalis. With vegetable alkali it forms a crystallizable salt, soluble in eight times its quantity of boiling water, and separable for the most part by cooling. With the mineral alkali it forms a salt, which requires only five parts of boiling water for its solution. Both these salts are perfectly neutral. When saturated with volatile alkali it forms a salt, which, after being gently dried, has a sourish taste. It does not perceptibly act on the metals; but, forms with their calces, in solution, salts of very difficult solubility, which are therefore precipitated*.

The principles of milk appear to be united together partly in a chemical, and partly in a mechanical manner; and the butter seems to rise to the top, in consequence of the greater specific gravity of the whey through which it is dispersed. Cream consists of butter mixed with much whey and curd. It is generally thought that the separation of the butter by churning, is effected simply by the agitation, which causes the fatty particles to strike against each other, and coagulate into larger masses. There seems, however, some reason to think that a chemical effect takes place in this operation; in which, the intimate mixture of atmospheric air with the fluid may perhaps have some effect.

Butter appears to be of the nature of fat oils; but is considered by most nations as infinitely preferable to them, as an article of food. By distillation on a

* On milk and its acid, and on the acid of the sugar of milk, consult the Chemical Essays of Scheele.

water-bath it gives out the aqueous fluid, which, from the manner of its fabrication, is distributed through its mass. Its products by destructive distillation nearly resemble those of other oils. They consist of an acid of a strong and penetrating smell, a fluid oil, and a concrete oil of the same smell as the acid. These oils, like others obtained in similar circumstances, may, by repeated rectifications, be converted into volatile oils, of the nature of those which are called essential. In other respects, butter possesses the same properties, and may be applied to the same uses as fat oils. It becomes rancid by spontaneous decomposition, which develops its acid; and with fixed alkalis it forms soap.

The eggs of birds considerably resemble milk in their component parts, though their peculiar structure and organization constitute a great and essential difference, applicable to the purposes of generation, into which our present views do not require us to proceed. The white of egg does not greatly differ from the curd of milk or cheese. When it is mixed with water, it forms a coagulum or curd by the addition of acids. Heat coagulates the white of egg, without depriving it of weight; which is a very singular fact, and has not yet been well explained. The white of egg, however, appears to differ, in some respects, from curd. It is said to afford a small portion of sulphur by sublimation; and it contains the mineral alkali in a disengaged state.

The yolk of egg appears to be an animal emulsion, which is diffusible in water. It contains an oil, which may be separated by drying, and afterwards subjecting it to pressure. See ACID OF MILK, BUTTER, and CHEESE.

MILLIPEDES. The millipedes, *aselli*, *porcelli*, *onisci*, &c. presented certain peculiar circumstances in their analysis, made by M. Thouvenel. By distillation on the water-bath, without addition, they afford an insipid and alkaline phlegm, sometimes effervescing with acid, and converting the syrup of violets to a green: in this operation they lost five-eighths of their weight. By treatment with water and spirit of wine, they afterwards afforded two drachms of soluble matter in the ounce; of which more than two thirds were extractive matter, and the residue an oily or extractive substance. These two matters were easily separated by ether, which dissolves the latter without touching the extract; they differ from those of cantharides, and ants, in affording more concrete volatile alkali, and no acid in their distillation. M. Thouvenel observes, on this subject, that among insects the millipedes appear to have the same relation to cantharides and ants, which reptiles have with respect to quadrupeds.

The neutral salts contained in these insects are very small in quantity, and very difficult to be extracted. M. Thouvenel affirms, that the millipedes, earthworms, and lumbrici, constantly afforded him marine salt, with earthy bases, and base of vegetable alkali; while in ants and cantharides, these two bases, the first of which always appeared to him the most abundant, are united with an acid, which has the character of the phosphoric acid. It is necessary to be observed here, that this chemist, in his Dissertation, has not described either the methods of extracting these salts, or the processes he made use of to ascertain their nature.

MINERALOGY AND MINERALS. Every substance which does not possess organization, or is not the immediate product of some organized body, belongs to the mineral kingdom. Among the numerous variety of materials which demand the attention and exercise the ingenuity of the chemist and the manufacturer, some are compounded of such principles, and formed under such circumstances and situations in the earth, that it is difficult to distinguish them without recurring to the test of experiment. Others are formed with considerable

regularity as to the proportion of their principles, their colour, fracture, specific gravity, and crystallized figure. Every practical mineralogist is naturally disposed to avail himself of the external figure and obvious characters of bodies, to distinguish them from each other, and we daily see instances of great skill in this method of discrimination. It happens unfortunately however for the acquisition of this branch of knowledge, that the differences depend upon circumstances, which, for the most part, are scarcely communicable by mere description, without the exhibition of specimens. Hence it has in many instances happened, that chemists have obtained possession of quantities of minerals, the names of which they could not with any degree of certainty ascertain, until they had made some experiments to determine their component parts. Much industry has been employed with success in simplifying the experiments with re-agents, and with the blow-pipe, for this purpose. Thus it has arisen that mineralogy has been assiduously cultivated by two different descriptions of men. The one have noted the figures, measured the angles, described the colours, transparency, opacity, texture as ascertained by fracture, hardness, and the like evident properties; the other have passed slightly over these indications, and have attended chiefly to such component parts, as chemical analysis exhibits. The best system for the classification of minerals must be that in which the external characters, as well as the component parts, are noticed; for there is no reason why we should neglect any of the means of obtaining an accurate knowledge of bodies. The component parts or principles of minerals afford the great outlines for classing them under general species and varieties; and their external appearances, when not sufficiently decisive to the observer, will always be useful to point out the experiments he must make to ascertain their place. The modern systems of Bergman, Kirwan, and Chaptal, are grounded on considerations of this nature*. See ANALYSIS and BLOW-PIPE.

MINERALIZER. Metallic substances are said to be mineralized when deprived of their usual properties by combination with some other substance. The commonest mineralizers are sulphur, arsenic, and fixed air. Vital air is as common as any, but is not usually reckoned among mineralizers, on account of the phlogistic theory, which, in a great measure, overlooks the agency of this substance in calcination. Arsenic is likewise excluded from mineralizers, by some writers, who affirm that it is always united to metals in its metallic state. But as there are good reasons to conclude that it exists in such combinations in the form of calx or acid, the argument cannot be admitted as conclusive. The vitriolic and marine acids are less common mineralizers. The phosphoric acid exists in the green lead ore, and less evidently in some of the ores of iron. Fixed air exists in the calciform ores.

MINES. See METALLURGY.

MINIUM. Red lead, or minium, may be made directly from lead, and also from litharge, which can be had cheaper from various processes where lead is employed. But this last red lead is not so good as the former, on account of the

* For general systems of mineralogy the English reader may recur to the following works: Cronstedt's Essay towards a System of Mineralogy, edited by Magellan, in two vols. octavo. Kirwan's Elements of Mineralogy. Outlines of Mineralogy, by Bergman; Mongez has re-published this work in French, with very large additions; but, unfortunately for science, it is not translated, and of course not easily obtained in this country. The Mineralogical System of Daubenton is inserted entire in Fourcroy's Elements of Natural History and Chemistry. And a concise system, of later date than these, may be found in the second volume of Chaptal's Chemistry.

scoria of other substances mixed with the litharge. The makers of flint glass, who use much red lead in the composition of that glass, find that it does not flux so well as that made from the direct calcination of the metal, as practised in the county of Derby, where no less than nine mills, or furnaces, are kept on this operation. These furnaces are very like a baker's oven, with a low vaulted roof, and two party walls, rising from their floor, which leave a middle space, where the pit coal is burned: the flame being drawn over the party walls, strikes on the roof, and is from thence reflected on each side, by which the lead there kept is melted. The surface of lead, by its exposition to air, becomes instantly covered with a dusky pellicle; this is successively removed, and the greatest part of the metal is converted into a yellowish-green powder: this is afterwards ground fine in a mill, and washed; the heterogeneous particles of lead, still in being, are separated by passing the wash through sieves; the yellow colour becomes uniform, and is called massicot by the painters. These yellow calces being well dried, are thrown again into the furnace, where they are constantly stirred in a continued heat; so that in about 48 hours, these calces acquire a vivid red, inclining to orange colour, and are known by the name of minium, or red lead. M. de Machy was certainly mistaken, when he asserted that the calcination alone, without the contact of the flame and smoke, was capable of producing a good colour. But the red lead made in France is of a considerably worse quality than what is made in England or Holland. A ton, or twenty hundred weight, of lead generally gives twenty-two hundred weight of minium. It is said, that at Nuremberg the increased weight of red lead amounts to one-fifth of the metal; this may probably depend on the method employed, as Watson thinks. Neumann says, that the best Venetian minium is made out of ceruse, or white lead. Magellan.

MIRABILE SAL. Glauber's salt, or the combination of vitriolic acid with the mineral alkali, has been pretty generally known by the name of sal mirabile Glauberi, who obtained it from the residue, after distilling marine acid from a mixture of common salt and the acid of vitriol.

MIRACLE CHEMICAL. If to a concentrated solution of Epsom salt, or the combinations of magnesia with the nitrous or marine acid, a like solution of fixed alkali be added, the magnesia is separated immediately in so large a quantity that the mixture becomes nearly solid. This sudden conversion of two fluids into a solid has been called the chemical miracle.

MIRRORS. See *SPECULUM*; also *SILVERING*.

MISPICKEL. An ore of iron consisting of that metal mineralized by arsenic. It is called speis by the Bohemians. Its colour is generally of a bright white, resembling a mixture of silver and tin, sometimes, though seldom, variegated like a pigeon's neck, and is not easily altered by exposure to the air. Its form is either granular, cuspidated, cuneiform, prismatic, or rhomboidal. It is magnetic neither before nor after calcination, is soluble in acids, affords arsenic by distillation in the proportion of 30 or 40 per cent. and sometimes contains a small proportion of copper and silver. It is frequently mixed with other metallic ores, and often found in indurated clay, quartz, spar, shorl, &c.

When iron contains less than one sixteenth of arsenic, it is magnetic; therefore, if the calcination be pushed so far, the iron will remain magnetic. It may be analysed by solution in the marine acid, which will take up the iron, and leave the arsenic; or by solution in aqua regia, which will take up both; but water being added, will precipitate the arsenic and leave the iron. The silver will remain in

the form of horn silver, and the copper may be separated by the methods mentioned under that article.

MIXTURE. This term was formerly used to denote what chemists now mean by combination. At present it is applied to distinguish that aggregation which takes place when powders or liquids, not disposed to combine from defect of temperature, or any other cause, are added together. Thus sand and an alkali may be mixed together, without any perceptible combination or change of their respective properties; but if the temperature be raised to that of strong fusion, they combine, and form glass, the principles of which are no longer in a state of mere mixture.

MOCHA or MOCHO STONE. The achate, when it contains arborization, or small figures of trees or moss, is called the mocho stone.

MOCK LEAD. An ore of zinc. See **BLÉNDE**.

MOLYBDENA, like manganese and wolfram, has not been reduced into masses of any considerable magnitude; but has been obtained only in small separate globules, in a blackish brilliant mass. It has been revived by a process similar to that by which regulus of manganese (see **MANGANESE**) is obtained; but it requires a most extreme degree of heat for that purpose. The globules are grey, brittle, and extremely infusible. By heat it is converted into a white calx, which rises in brilliant needle-formed flowers, like those of antimony. Nitrous acid readily calcines and acidifies the regulus. Nitre detonates with it, and the remaining alkali combines with its calx.

Detonation with nitre decomposes the native molybdena; but solution in nitrous acid is the readiest way to procure the acid of this substance. Prussian alkali, and also infusion of galls, precipitate the acid from its solutions. When acid of arsenic is heated with molybdena, it converts part of the sulphur into volatile vitriolic acid; which comes over, and combines with another portion, with which it rises in the form of orpiment. No other acids but the nitrous and arsenical have any action on crude molybdena. The regulus of molybdena unites with several of the metals, and forms brittle or friable compounds.

This mineral is scarce. It is distinguishable from black lead by its more shining scaly appearance, and marks paper with a more brilliant stroke; and, as it resembles no other substance, it does not require to be assayed.

MOON STONE. The moon stone is of a clear white colour, approaching to that of milk. When looked at in a certain position, it reflects a strong light, like the mother of pearl; and some specimens exhibit spots of a carnation colour. It is found in obtuse-angular pieces, which sometimes have a quadrangular figure. Its fracture is evidently foliated. It is very hard, and in other respects agrees with common felspar. Probably it is the androdamas of Pliny; the common girasole of the Italians; and the water opal of Ceylon. It is sometimes classed with the opal, and by others with the cat's-eye.

This stone is of the chalcedony or pseudo-opal kind; it reflects a whitish light, with some various shades of a few intermixed colours on a blueish bottom, like the shining face of the moon, when it is high enough not to become reddish by the interference of the earthy vapours.

The rainbow-stone, or iris, seems to be nothing else than a moon-stone, in which the yellow, purple, and blue reflected rays are the most conspicuous. Magellan.

MOOR-STONE. See **GRANITE**.

MORTAR. See **LIME**. Also a well-known instrument for pulverizing.
MOSAIC GOLD. See **AURUM MUSIVUM**. Also **TIN**.

MOSS. See **ARCHIL**.

MOTHER WATER, OR MOTHER LEY. When sea-water, or any other solution containing various salts, is evaporated, and the crystals taken out; there always remains a fluid containing deliquescent salts, and the impurities if present. This is called the mother-water, and requires to be variously treated according to the nature of its contents. Inflammable matters are destroyed by evaporation to dryness and ignition in an open vessel. The saline matters may be afterwards taken up by the addition of pure water. In other instances the mother-water is largely diluted, and such additions made as may either precipitate part of its contents, or form such new combinations as the operator is desirous of procuring. See **MAGNESIA**; also **ANALYSIS**.

MOULD. See **ARABLE LAND**, **EARTH VEGETABLE**, and **MARLE**.

MOUNTAIN. When we contemplate the surface of the globe in populous districts, our attention is chiefly directed to the agency of man, and those energies of social life, which produce, modify, and change the prospect around us. But when we enter the wild and romantic scene of a mountainous country, we are every where struck with the vestiges of operations carried on by the powers of nature, through a long series of ages, and upon a scale prodigiously greater than any to which the works of man can be extended. We meditate on the surrounding scene with an emotion resembling that produced by the view of a pile of ruins long since gone to decay. We endeavour to investigate what may have been the original state of the pile, and, for want of information, our conclusions are for the most part little better founded than those of an amusing reverie. If the life of man had permitted the philosopher to follow, during the revolution of centuries, that variety of changes produced on the surface of the earth by the numerous agents which alter it, we should at this time have been in possession of the most valuable information respecting these great phenomena: but confined as we are to a small spot of the universe, we fix our attention for the transient moment of our existence upon operations of prodigious duration, far remote from their commencement, or termination. It is no wonder then that, in many instances, we find it difficult to comprehend, and in many more to imitate, these vast processes.

In whatever manner the original formation of this globe may have been accomplished; by what processes of fire, or water, it may have been chiefly modified; to what secondary circumstances its particular place in the solar system, and its great movements, may be owing;—these subjects have employed the pens of religious writers, as well as of the bold constructors of imaginary systems. It is but too easy to accommodate facts imperfectly known to a favourite hypothesis: but it becomes the philosopher rather to analyse than to combine too hastily; and though knowledge may be considered as the classification of facts, it is certain that too much haste in this classifying is productive of error. The investigator of natural appearances ought not to be impatient under a state of doubt and obscurity. The first step to solid knowledge is to consider what now exists, and thence to deduce what may have heretofore existed.

It appears, from a great variety of observations, that the internal part of the globe consists of the stone called granite. It is this which shews itself as the limit of all the excavations made on the surface of our planet, either by natural causes or the art of man. The degradations and sublequent changes which this rock undergoes

undergoes by the action of water, and which therefore it must have undergone in times past, are so well delineated by Chaptal, that I shall extract his observations in this place.

This fluid, collected in the cavity of the ocean, is carried by the winds to the tops of the most elevated mountains, where it is precipitated in rain, and forms torrents, which return with various degrees of rapidity into the common reservoir.

Such an uninterrupted motion and fall must gradually attenuate, and wear away the hardest rocks, and carry their pulverulent parts to distances more or less considerable. The action of the air, and the varying temperatures of the atmosphere, facilitate the attenuation and the destruction of these rocks. Heat dries their surface, and renders it more accessible, and more penetrable to the water which succeeds; cold divides them, by freezing the water which has entered into their texture; the air itself affords the carbonic acid, which attacks the lime-stone, and causes it to effloresce; the vital air unites to the iron, and calcines it: inasmuch that this concurrence of causes favours the disunion of principles; and consequently the action of water, which clears the surface, carries away the products of decomposition, and makes preparation for a succeeding process of the same nature.

The first effect of the rain is therefore to depress the mountains. But the stones which compose them must resist in proportion to their hardness; and we ought not to be surprised when we observe peaks which have braved the destructive action of time, and still remain to attest the primitive level of the mountains which have disappeared. The primitive rocks, alike inaccessible to the injury of ages as to the animated beings which cover less elevated mountains with their remains, may be considered as the source or origin of rivers or streams. The water which falls on their summits, flows down in torrents by their lateral surfaces. In its course it wears away the soil upon which it incessantly acts. It hollows out a bed of a depth proportioned to the rapidity of its course, the quantity of its waters, and the hardness of the rock over which it flows; at the same time that it carries along with it portions and fragments of such stones as it loosens in its course.

These stones, rolled along by the water, must strike together, and break off their projecting angles; a process that must quickly have afforded those rounded flints which form the pebbles of rivers. These pebbles are found to diminish in size, in proportion to the distance from the mountain which affords them: and it is to this cause that M. Dorthes has referred the disproportionate magnitude of the pebbles which form our ancient worn stones, when compared with those of modern date: for the sea extending itself formerly much more inland, in the direction of the Rhone, the stones which it received from the rivers, and threw back again upon the shores, had not run through so long a space in their beds as those which they at present pass over. Thus it is that the remains of the Alps, carried along by the Rhone, have successively covered the vast interval comprised between the mountains of Dauphiny and Vivarais; and are carried into our seas, which deposit them in small pebbles on the shore.

The pulverulent remains of mountains, or the powder which results from the rounding of these flints, are carried along with greater facility than the flints themselves: they float for a long time in the water, whose transparency they impair: and when these said waters are less agitated, and their course becomes slackened, they are deposited in a fine and light paste, forming beds more or less thick, and of the same nature as that of the rocks to which they owe their origin. These strata

gradually become drier by the agglutination of their principles; they become consistent, acquire hardness, and form siliceous clays, *filex*, *petrofilex*, and all the numerous class of pebbles which are found dispersed in strata, or in banks in the ancient beds of rivers.

Mr. Pallas has observed the transition of clay to the state of *filex* in the brook of *Sungbir*, near *Wolodimir*. Mr. G. W. Baumer has likewise observed it in *Upper Hesse*.

The mud is much more frequently deposited in the interstices left between the rounded flints themselves, which intervals it fills, and there forms a true cement that becomes hard, and constitutes the compound stones known by the name of *pudding-stones* and *grit-stones*; for these two kinds of stones do not appear to me to differ but in the coarseness of the grain which forms them, and the cement which connects them together.

We sometimes observe the granite spontaneously decomposed. The texture of the stones which form it has been destroyed; the principles, or component parts, are disunited and separated, and they are gradually carried away by the waters. *Chaptal* observed near *Mende*, towards *Castelnouvel*, the most beautiful *kaolin* on the surface of a granite, in a state of decomposition; and this same rock is decomposed in several other places. It appeared to him that the feld spar was particularly subject to be altered the first.

Most siliceous stones, formed by the deposition of fluvial waters, and hardened by the lapse of time, are easily subjected to a second decomposition. Iron is the principal agent of these secondary alterations; and its calcination, determined by air or water, produces a disunion of principles. Nature may be observed in this process, by an attentive examination of such alterations as *gun flints*, *variolites*, *porphyries*, *jaspers*, and the like, are subjected to.

The decomposition of flints, *chalcidones*, *agates*, and generally all stones of this kind which possess a certain degree of transparency, appears to *Chaptal* to be referable to the volatilization of the water, which forms one of their principles, and is the cause of their transparency.

These stones may be considered as commencements of crystallization; and when the water is dissipated, they effervesce after the manner of certain neutral salts. Hence it arises that the decomposition is announced by opacity, a white colour, loss of consistence and hardness; and terminates by forming a very attenuated powder, sometimes of extreme whiteness. It is this decomposition, more particularly, which forms clays.

There are flints whose alterations form effervescent marles. These do not appear to *Chaptal* to be of the nature of primitive rocks: they have the same origin as the calcareous stones, from which they differ only in consequence of a very considerable proportion of clay. The stones which we so abundantly find of this nature around us, among calcareous decompositions, may be considered as of this kind.

Water filtrating through mountains of primitive rock, frequently carries along with it very minutely divided particles of quartz; and proceeds to form, by deposition, *stalactites*, *agates*, *rock crystal*, &c.

These *quartzose stalactites*, differently coloured, are of a formation considerably analogous to that of calcareous alabasters; and we perceive no other difference between them than that of their constituent parts.

Thus far we have exhibited, in a few words, the principal changes, and various modifications, to which the primitive rocks have been subjected. We have not observed either germination or life: and the metals, sulphur, and bitumens, have
not

not hitherto presented themselves to our observation. Their formation appears to be posterior to the existence of this primitive globe ; and the alterations and decompositions which now remain to be enquired into, appear to be produced by the class of living or organized beings.

On the one hand, we behold the numerous class of shell animals, which cause the stony mass of our globe to increase by their remains. The spoils of these creatures, long agitated and driven about by the waves, and more or less altered by collision, form those strata and banks of lime-stone, in which we very often perceive impressions of those shells to which they owe their origin.

On the other hand, we observe a numerous quantity of vegetables that grow and perish in the sea ; and these plants likewise, deposited and heaped together by the currents, form strata, which are decomposed, lose their organization, and leave all the principles of the vegetable confounded with the earthy principle. It is to this source that the origin of pit-coal, and secondary schistus, is usually attributed ; and this theory is established on the existence of the texture of decomposed vegetables very usually seen in schistus and coal, and likewise on the presence of shells and fish in most of these products.

It appears to Chaptal, that the formation of pyrites ought to be attributed to the decomposition of vegetables : it exists in greater or less abundance in all schistus and coal. He found a wooden shovel buried in the depositions of the river De Ceze, converted into jet and pyrites. The decomposition of animal substances may be added to this cause : and it appears to be a confirmation of these ideas, that we find many shells passed to the state of pyrites.

Not only the marine vegetables form considerable strata by their decomposition ; but the remains of those which grow on the surface of the globe ought to be considered among the causes or agents which concur in producing changes upon that surface.

We shall separately consider how much is owing to each of these causes ; and shall follow the effects of each, as if that cause alone were employed in modifying and altering our planet.

1. The calcareous mountains are constantly placed upon the surface of the primitive mountains ; and though a few solitary observations present a contrary order, we ought to consider this inversion and derangement as produced by shocks which have changed the primitive disposition. It must be observed also, that the disorder is sometimes merely apparent ; and that some naturalists of little information have described calcareous mountains as inclining beneath the granite, because this last pierces, as it were, through the envelope, rises to a greater height, and leaves at its feet, almost beneath it, the calcareous remains deposited at its base.

Sometimes even the lime-stone fills to a very great depth the crevices or clefts formed in the granite. In Gevaudan, towards Florac, there is a profound cavity in the granite filled with calcareous stone. This vein is known to possess a depth of more than one hundred and fifty toises, with a diameter of about two or three.

It likewise happens frequently enough, that such waters as are loaded with the remains of the primitive granite heap them together, and form secondary granites, which may exist above the calcareous stone.

These calcareous mountains are decomposed by the combined action of air and water ; and this fluid, which does not possess the property of holding it in solution, soon deposits it in the form of gurns, alabasters, stalactites, &c. Spars owe their formation.

formation to no other cause. Their crystallization is posterior to the origin of calcareous mountains.

Waters wear down and carry away calcareous mountains with greater ease than the primitive mountains : their remains being very light, are rolled along, and more or less worn. The fragments of these rocks are sometimes connected by a gluten or cement of the same nature ; from which process calcareous grit and breccias arise. These calcareous remains formerly deposited themselves upon the quartzose sand ; and the union of primitive matter and secondary products gives rise to a rock of a mixed nature, which is common in our province.

2. The mountains of secondary schistus frequently exhibit to us a pure mixture of earthy principles, without the smallest vestige of bitumen. These rocks afford, by analysis, silex, clay, magnesia, lime in the state of carbonate, or mild, and iron ; principles which are more or less united, and consequently accessible in various degrees to the action of such agents as destroy the rocks hitherto treated of.

These same principles, when disunited, and carried away by waters, give rise to a great part of the stones comprised in the magnesian genus. The same elements worn down by the waters, and deposited under circumstances proper to facilitate crystallization, form the schorls, tourmaline, garnets, &c.

Chaptal does not pretend by this to exclude and absolutely reject the system of such naturalists as attribute the formation of magnesian stones to the decomposition of the primitive rocks. But he thinks that this formation cannot be objected to for several of them, more especially such as contain magnesia in the greatest abundance.

It frequently happens that the secondary schisti are interspersed with pyrites ; and, in this case, the simple contact of air and water facilitates their decomposition. Sulphuric acid is thus formed, which combines with the various constituent principles of the stone ; whence result the sulphates or vitriols of iron, of magnesia, of clay, and of lime, which effloresce at the surface, and remain confounded together. Schisti of this nature are wrought in most places where alum works have been established ; and the most laborious part of this undertaking consists in separating the sulphates of iron, of lime, and of magnesia from each other, which are mixed together. Sometimes the magnesia is so abundant that its sulphate predominates : Chaptal observed mountains of schistus of this nature. The sulphate of lime being very sparingly soluble in water, is carried away by that liquid, and deposited to form gypsum ; while the other more soluble salts remaining suspended, form viriolic mineral waters.

The pyritous schisti are frequently impregnated with bitumen, and the proportions constitute the various qualities of pit-coal.

It appears to Chaptal, that we may lay it down as an incontestable principle, that the pyrites is abundant in proportion as the bituminous principle is more scarce. Hence it arises, that coals of a bad quality are the most sulphureous, and destroy metallic vessels by converting them into pyrites. The focus of volcanos appears to be formed by a schistus of this nature ; and in the analyses of the stony matters which are ejected, we find the same principles as those which constitute this schistus. We ought not therefore to be much surprised at finding schorls among volcanic products ; and still less at observing that subterranean fires throw sulphuric salts, sulphur, and other analogous products out of the entrails of the earth.

3. The remains of terrestrial vegetables exhibit a mixture of primitive earths more or less coloured by iron : we may therefore consider these as a matrix in which the seeds of all stony combinations are dispersed. The earthy principles assort themselves according to the laws of their affinities ; and form crystals of spar, of plaster, and even the rock crystals, according to all appearance : for we find ochreous earths in which these crystals are abundantly dispersed ; we see them formed almost under our eyes. We may frequently observe indurated ochres full of these crystals terminating in two pyramids.

The ochreous earths appear to deserve the greatest attention of naturalists. They constitute one of the most fertile means of action which nature employs : and it is even in earths nearly similar to these that she elaborates the diamond, in the kingdoms of Golconda and Visapour. If it were allowable, says our author, to indulge in a fiction purely poetical, we might affirm that the element of fire, so far from being lost by the dispersion of the combustible principles of vegetables, becomes purified to form this precious stone so eminently combustible ; that nature has been desirous of proving that the terms destruction and death are relative only to the imperfection of our senses ; and that she is never more fruitful than when we suppose her to be at the moment of extinction.

The spoils of animals, which live on the surface of the globe, are entitled to some consideration among the number of causes which we assign to explain the various changes our planet is subjected to. We find bones in a state of considerable preservation in certain places ; we can even frequently enough distinguish the species of the animals to which they have belonged. From indications of this sort it is that some writers have endeavoured to explain the disappearance of certain species ; and to draw conclusions from thence, either that our planet is perceptibly cooled, or that a sensible change has taken place in the position of the axis of the earth. The phosphoric salts and phosphorus, which have been found, in our time, in combination with lead, iron, &c. prove that, in proportion as the principles are disengaged by animal decomposition, they combine with other bodies, and form the nitrous acid, the alkalis, and in general all the numerous kinds of nitrous salts.

MOUNTAIN BLUE. An ore of copper of a blue colour, most frequently of a loose pulverulent form, but sometimes indurated and even crystallized, but then it is mixed with quartz. One hundred parts of it, according to Kirwan, contain about sixty-nine of copper, twenty-nine of fixed air, and two of water. Morveau, in the Memoirs of Dijon for 1782, quoted by this author, shews that the calces of copper are determined rather to a blue than a green colour, by a greater proportion of phlogiston, viz. the metal is nearer the metallic state.

These ores are analysed in the moist way by solution in acids, and precipitation by the mineral aerated alkali, if they be pure, or by the Prussian alkali, if they contain earths. One hundred and ninety-four grains of the precipitate formed by the mineral alkali, are equivalent to 100 of copper in its metallic state : so also are 350 grains of the precipitate formed by the Prussian alkali, as Mr. Bergman has determined : copper also may be precipitated in its metallic state by means of iron, though it is not easy to get it pure, if the nitrous acid be the solvent.

In the dry way, after torrefaction, they may be essayed by melting them with one-half or three-fourths of their weight of borax, and one-fourth of their weight of pitch. Some loss always attends the black flux.

MOUNTAIN GREEN is generally found in a loose and friable state, rarely crystallized and indurated, often mixed with calcareous earth and iron, and

some

some arsenic. One hundred parts of the purest contain 72 of copper, 22 of aerial acid, and 6 of water. See also MALACHITE.

MUCILAGE. A general term used to denote a substance, soluble in water, whether hot or cold, with which it forms a transparent adhesive or gluey mass. When obtained from vegetables, it is distinguished by the name of GUM; when from animal substances, it is called GLUE, or JELLY. Consult the the articles.

When animal mucilage has been extracted without long boiling, it then possesses most of the characters of gum. It is thought that the difference between gum and glue consists in the mixture of serum in the latter. It is probable however, that the principles which render glue more disposed to the putrid fermentation instead of the acidity acquired by gums, are not merely mixed, but intimately combined.

MUFFLE. A small earthen oven made and sold by the crucible manufacturers. It is to be fixed in a furnace, and is useful for cupellation, and other processes which demand access of air.

MUMIA. This was found in the sea on the coasts of Finland, in the year 1736; it is perfectly white, and of the consistence of tallow, but more brittle, though as greasy. Its specific gravity is 0,770, whereas that of tallow is 0,969; it burns with a blue flame, and a smell of grease, leaving a black viscid matter, which is more difficultly consumed: it is soluble in spirit of wine only when tartarised, and even then leaves an insoluble residuum, but expressed oils dissolve it when boiling. It is also found in some rocky parts of Persia, but seems mixed with petrol, and is there called Schebennaad, Tienpen, Kodreti*. Mr. Herman, a physician of Strasburgh, mentions a spring in the neighbourhood of that city, which contains a substance of this sort diffused through it, which separates on ebullition, and may then be collected. Kirwan.

MURIATIC ACID. See ACID MARINE.

MUSCOVY GLASS consists of broad, elastic, flexible, transparent leaves, and differs externally from mica, only in being softer, and more soapy to the touch. It is capable of being split into laminæ of the two or three hundredth part of an inch thick, and the plates naturally exhibit a strong electric state, and sparks, when torn asunder in the dark, even though previous friction be carefully avoided. Few specimens are as transparent as glass.

MUSK. See CIVET.

MUST. The juice of the grape previous to the commencement of fermentation. The word is likewise occasionally used to denote other saccharine juices in the same state.

MYRRH. A gum resin, brought from the East Indies, and likewise from Alexandria, Smyrna, and Aleppo. It is hard, dry, glossy, of various colours, yellowish, reddish, brown, yellowish-brown, reddish-brown, blackish, intermixed with whitish specks or tears, transparent like agate, or opaque like pitch, of a peculiar strong smell, and a bitter somewhat biting taste. The best is that which is of a reddish-brown colour, not verging too much to yellowish or blackish; uniform on the outside, internally specked or streaked with white, clear and bright, somewhat unctuous to the touch, but not tenacious so as to stick to the fingers.

This gummy resin is liable to great abuses: the larger masses in particular are frequently no other than some artificial composition, skilfully incrustated on

* Mem. Sued. 87. 2 Lin. von Gmel. 389. Gerh. Beytr. 211.

the outside with a solution of myrrh. Some report that bdellium is nearly allied to myrrh, and not easily to be distinguished from it; the differences however are sufficiently obvious, bdellium being darker coloured and less transparent than good myrrh, internally soft and tenacious (which myrrh never is), yielding a quite different smell, and wanting its bitterness.

From sixteen ounces of myrrh Neumann obtained, by means of water, twelve and a half of gummy extract; and from the residuum by rectified spirit, one and a half of resin. On treating the same quantity first with spirit, and afterwards with water, he obtained five ounces of resinous and eight ounces six drams of gummy extract. The indissoluble matter amounted in both operations to two ounces, or one eighth of the myrrh.

In distillation with water, an essential oil arises, to the quantity of three drams from a pound. This oil smells and tastes extremely strong of the myrrh, and contains all that part in which the peculiar qualities of the juice reside: it differs remarkably from that of the other gummy resins, in not being hot or pungent, in being so ponderous as to sink in water, and in not being in the least elevated by spirit of wine; highly rectified spirit, distilled from myrrh, receiving no sensible impregnation either in smell or taste.

It is further observable, that whether myrrh be digested in water or in spirit, the whole of its smell and taste is taken up by the menstruum applied first: the extracts made by water after spirit has performed its office, as well as that by spirit after water, are inodorous and insipid. Both the tincture and the extract made by pure spirit at first, contain all the active parts of the myrrh. The watery infusion or decoction, if made in such a manner as to prevent evaporation, does the same; but on exhaling it to the consistence of an extract, all the flavour of the myrrh is lost, and nothing but its bitterness remains: no one can distinguish in the watery extract any thing of the specific characters of the myrrh. From these experiments we learn in what manner this juice is to be treated to the best advantage, and in what preparations its virtues are preserved or lost.

On inclosing some powdered myrrh in the white of a hard boiled egg, and setting it in a moist cellar, the liquor into which the egg is by degrees resolved, extracts nearly all the smell and taste of the myrrh. This liquor, commonly called *Oleum myrrhæ per deliquium*, is precipitated or coagulated by spirit of wine; and the unctuous coagulum, separated from the spirit, dissolves again in pure water. This process has been applied likewise to mastich and other pure resins; but from those the white of eggs extracts nothing.

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NAPHTHA. A fine thin fragrant colourless oil, which issues out of white, yellow, or black clays in Persia and Media, is known by this name. It burns with a bluish yellow flame, and is as inflammable as æther, and, like it, extracts gold

gold from aqua regia. It is not decomposed by distillation; and yet, if long exposed to the air, it changes colour, thickens, and degenerates into petrol. Its smell is very different from that of vegetable oils; it dissolves resins and balsams; but not gum resins, nor elastic gum. It dissolves the essential oils of thyme and lavender; but is insoluble in spirit of wine and æther. Its specific gravity is 0,708.

NARD INDIAN, or SPIKE-NARD, consists of a number of slender brittle filaments, supposed by some to be the root, by others, the pedicle of the leaves of a plant of the grass or rush kind; but which are properly the head of a root, for Pomet mentions and figures a specimen, which had great part of the root adhering.

Spikenard has a very strong, not agreeable smell and taste, scarce to be concealed or overpowered by a large admixture of other substances. In the Theriaca Cœlestis, a composition of many drugs of strong smells and tastes, spikenard enters but in small quantity, and yet it prevails over all the others. It contains, however, only a small proportion of essential oil: on distilling an ounce, there was only an appearance of some oily particles on the surface of the water. Rectified spirit brings over nothing: the spirituous extract possesses both the smell and taste of the spikenard, in a much greater degree than the watery. An ounce yielded a dram of spirituous, and afterwards forty-six grains of watery extract; water applied at first extracted from the same quantity four scruples, and spirit afterwards twenty-five grains: the indissoluble residuum weighed in both cases six drams ten grains.

NATRON, or NATRUM. A native alkaline salt, of the nature of the mineral, or marine alkali, which is found crystallized in Egypt, and other hot countries, in sands which surround lakes of salt water. There is no doubt but the common salt is decomposed, and loses its acid; but whether by the action of the air, of the mere heat of the sun, or, which is more probable, the effect of its light, has not been determined. In the new nomenclature of our College of Physicians, the mineral alkali is called natron.

NAUTILITES. A calcareous stone, or petrification of the nautilus. Some writers, who have called these serpent-stones, and supposed them to have been produced by a petrification of that creature, have expressed their surprise that the head is always wanting.

NEPHRITIC STONE. See JADE.

NEPHRITIC WOOD. This wood gives a blue colour to spirit of wine, or to water. This colour is changed to a yellow by acids, and afterwards restored to a blue by alkalis. Dr. Lewis observes, that it is the only woody matter which gives a blue tincture; and that this is the only vegetable blue which is thus destructible by acids.

NEUTRAL SALTS. This term is applied to all salts which contain an acid saturated with an alkali, an earth, or a metal. Bergmann confined it to salts containing alkali; and he called the earthy and metallic salts, middle salts. It is most usual to call the alkaline salts with an acid neutral, and to distinguish the others by the respective appellations, earthy and metallic.

NICKEL is a reddish white metallic substance, of great hardness, and of an uniform texture; very difficult to be purified, and always magnetical, whence it has been supposed to contain iron in its purest state. It is malleable, and is scarcely more fusible than pure iron. Its calces are of a green colour.

This metallic substance has not been applied to any use; and the chief attention of those chemists who have examined it, has been directed to obtain it in a

state of purity; which, however, has not yet been accomplished. It is found either native or calciform; but most commonly mineralized in combination with arsenic, sulphur, cobalt, and iron in the ore, called kupfer nickel, or false copper. This is of a reddish yellow, or coppery colour; of a texture either uniform, granular, or scaly; bright in its fracture, and almost always covered with a green efflorescence of calx. Most of the sulphur and arsenic may be driven off by long continued roasting, and the occasional addition of charcoal, which prevents the arsenic from being rendered more fixed by calcination; and the green calx which remains may be fused by the strongest heat of a smith's forge, together with two or three times its weight of black flux. The regulus thus obtained is of a reddish white colour, and brittle; but is very far from being pure. Repeated calcinations for many hours, and reductions, scarcely deprive the regulus of iron; and it is still highly magnetic when purified to such a degree as to possess considerable malleability. Combination with sulphur, with liver of sulphur, detonation with nitre, and solution in the volatile alkali and vitriolic acid, did not deprive it of its magnetism.

When the regulus*, obtained by scorification and reduction, was combined with sulphur, and reduced again after the dissipation of the sulphur by strong heat, and the addition of charcoal, to promote the volatility of the arsenical contents, and this process was three times repeated; the reduced metal was so infusible, as not to run into a mass by the strongest heat of a smith's forge, continued for three quarters of an hour. Its colour was then whitish, mixed with a glittering kind of red; it was strongly magnetical; of a specific gravity of 8,66; and a globule of one line in diameter was extended by the hammer into a plate of upwards of three lines in diameter: so that it is, properly speaking, an entire metal, and not a semi-metal. It afforded a blue solution with the volatile alkali; and in nitrous acid its solution was of a full green.

Concentrated vitriolic acid acts upon the regulus of nickel, and corrodes it. The residue, after distillation of the acid, is a greyish powder; part of which is in the saline state, and affords green crystals by solution in water and evaporation.

The nitrous solution of this metal affords saline crystals. Alkalis precipitate it, and redissolve the precipitate. Nitre detonates with nickel in the dry way. Sulphur readily combines with it by fusion, as does likewise arsenic; and both adhere very pertinaciously to it, as has been already shewn.

Nickel has been thought to be a modification of iron. This conclusion is grounded chiefly on its magnetism, and the consideration of the very remarkable and different properties iron is known to be capable of assuming in its several states. Others have supposed it to be an alloy of copper with various metallic admixtures. The blue colour it affords with volatile alkali, is the chief circumstance which gave rise to this opinion. But it has been very properly observed †, that many of the known metals would scarcely have endured more severe trials than this substance has undergone, without shewing indications, at least as strong, against the supposition of their being distinct bodies, as any afforded by nickel; and consequently, that so long as no one is able to produce this metal from pure iron or copper, and to explain in an intelligible way the process by which it can be generated, we must continue to regard it as a peculiar substance, possessing distinct properties. The general opinions of the chemists concur in admitting the force of this reasoning.

* Bergman on Nickel, in vol. ii. of his Essays.

† Bergman, ii. 264.

NIHIL ALBUM, a name given to the white calx of zinc, driven up during the combustion of that semi-metal, or the treatment of ores which contain it.

NITRE. Nitre with an alkaline basis is found ready formed in the East Indies, in Spain, in the kingdom of Naples, and elsewhere, in considerable quantities, but more abundantly in combination with a calcareous basis. For the greater part of the nitre made use of is produced by a combination of circumstances which tend to compose and condense the acid of nitre. Nitrous acid appears to be produced in all situations where animal matters are completely decomposed, with access of air, and of proper substances with which it can readily combine. Grounds frequently trodden by cattle and impregnated with their excrements, or the walls of inhabited places where putrid animal vapours abound, such as slaughter-houses, drains, or the like, afford nitre by long exposure to the air. Artificial nitre beds are made by an attention to the circumstances in which this salt is produced by nature. Dry ditches are dug, and covered with sheds, open at the sides, to keep off the rain: these are filled with animal substances—such as dung, or other excrements, with the remains of vegetables, and old mortar, or other loose calcareous earth; this substance being found to be the best and most convenient receptacle for the acid to combine with. Occasional watering, and turning up from time to time, are necessary to accelerate the process, and increase the surfaces to which the air may apply. After a succession of many months, more or less, according to the management of the operation, in which the action of a regular current of fresh air is of the greatest importance, nitre is found in the mass. If the beds contained much vegetable matter, a considerable portion of the nitrous salt will be common saltpetre; but, if otherwise, the acid will, for the most part, be combined with the calcareous earth.

To extract the saltpetre from the mass of earthy matter, a number of large casks are prepared, with a cock at the bottom of each, and a quantity of straw within, to prevent its being stopped up. In these the matter is put, together with wood-ashes, either strewed at top, or added during the filling. Boiling water is then poured on, and suffered to stand for some time; after which it is drawn off, and other water added in the same manner, as long as any saline matter can be thus extracted. The weak brine is heated and passed through other tubs, until it becomes of considerable strength. It is then carried to the boiler, and contains nitre and other salts; the chief of which is common culinary salt, or the marine acid united to the mineral alkali, or sometimes to magnesia. It is the property of nitre to be much more soluble in hot than cold water; but common salt is soluble very nearly as much in cold as in hot water. Whenever, therefore, the evaporation is carried by boiling to a certain point, much of the common salt will fall to the bottom, for want of water to hold it in solution, though the nitre will remain suspended by virtue of the heat. The common salt thus separated is taken out with a perforated ladle, and a small quantity of the fluid is cooled, from time to time, that its concentration may be known by the nitre which crystallizes in it. When the fluid is sufficiently evaporated, it is taken out and cooled, and great part of the nitre separates in crystals; while the remaining common salt continues dissolved, because equally soluble in cold as in hot water. Subsequent evaporation of the residue will separate more nitre in the same manner.

This nitre, which is called nitre of the first boiling, contains some common salt; from which it may be purified by solution in a small quantity of water, and subsequent evaporation: for the crystals thus obtained are much less contaminated
with

with common salt than before ; because the proportion of water is so much larger, with respect to the small quantity contained by the nitre, that very little of it will crystallize. For nice purposes, the solution and crystallization of nitre are repeated four times. The crystals of nitre are usually of the form of six-sided flattened prisms, with dihedral summits. Its taste is penetrating ; but the cold produced by placing the salt to dissolve in the mouth, is such as to predominate over the real taste at first. Seven parts of water dissolve one of nitre, at the temperature of sixty degrees ; but boiling water dissolves its own weight.

If nitre be exposed to a strong heat, it melts, and becomes red hot ; and the volatile product is found to consist of fuming nitrous acid, a large quantity of vital air, and some phlogisticated air ; the alkali remaining behind, somewhat altered by a portion of the earth of the retort which it has dissolved. Most other nitrous salts give out vital air by the same treatment. The extreme difficulty of ascertaining the weights of aerial products, and of the fixed residues, renders it an embarrassing task to shew by real experiment what happens in this operation among the principles of nitre. See ACID NITROUS.

When a combustible body and nitre are brought into contact, either of them being previously heated red hot, the body is burned with great rapidity, no doubt by the vital air which the nitre affords by the heat ; for the experiment succeeds in vacuo, and also when the bodies are surrounded by any aerial fluid incapable of maintaining combustion. This rapid combustion, effected by means of nitre, is called *desflagration*, when it is performed by a successive burning of the parts of the body ; or *detonation*, when the combustion of the whole is performed in so short a time as to appear instantaneous. In this experiment, it is remarkable that the combustion is maintained by vital air which is not in the elastic state, but fixed in the nitre. Whence it should follow, that either the vital air, or the combustible body, even in the fixed state, has a great capacity for heat, of which it must contain a large quantity, on the hypothesis of heat being matter. Or, if heat be a mere commotion, it will follow, that though the quantity of agitation produced by the sudden coalition of particles, in the act of converting an elastic fluid into a dense body, be such as to produce a great effect in increasing the temperature ; yet the quantity is still so considerable, when vital air and combustible matter unite even in their dense state, as to cause the most intense degree of ignition. See GUNPOWDER.

NITRE (ALKALISED). This is the fixed alkali which remains after the nitrous acid has been destroyed by its detonation with any inflammable matter. This alkali is generally called *fixed nitre*.

NITRE (AMMONIACAL). The neutral salt resulting from the combination of the nitrous acid, to the point of saturation, with volatile alkali, has been thus named. See AMMONIACAL NITROUS SALT.

NITRE (CALCAREOUS), OR NITRE WITH EARTHY BASIS. Calcareous nitre is a neutral salt compounded of the nitrous acid combined to saturation with a calcareous earth. It is generally called *nitre* with an earthy basis, because the salts formed by the nitrous acid with the other earths have been less attended to.

Nitrous acid dissolves with great activity all calcareous earths and stones, calcined or uncalcined. It dissolves a large quantity of them, and leaves no residuum when they are pure. By this combination is formed a neutral salt very deliquescent. This salt is not susceptible of a true crystallization. It has a poignant, acrid, and bitter taste. If it be evaporated to dryness, it becomes solid,

solid, and seems to be an earthy matter, which does not detonate, or at least very weakly, with inflammable matters.

The adhesion of the acid to its basis is so weak, that if the salt be distilled in a retort, an acidulous phlegm will first pass over; and when the fire is increased, all the acid will follow, excepting a small portion which adheres more strongly, but which may be at last expelled by calcination in an open fire.

A great quantity of nitre with earthy basis is found ready formed in nitrous earths and stones. Nitre is most frequently produced in that form. This nitre may be decomposed by a fixed alkali, which unites with its acid and precipitates the earth, in the process for making saltpetre. The mother-waters obtained in these operations contain still a large quantity of this nitre with earthy basis. See the word NITRE in the preceding article.

NITRE (CUBIC or QUADRANGULAR). When nitrous acid is saturated with mineral alkali, a neutral salt is formed, susceptible of crystallization and of detonation, and consequently is a kind of nitre. This salt has all the essential properties of nitre with basis of fixed vegetable alkali; but the marine alkali, which is its basis, changes the form of its crystals, which are not channelled prisms, like those of ordinary nitre, but are cubes, or sometimes parallelopipedons, with rhomboidal faces. From these forms the salt has been called quadrangular nitre.

We may make quadrangular nitre by combining directly the nitrous acid to the point of saturation with the crystals of soda, or by precipitating with this alkali the solutions of earths and metals made by nitrous acid, or by precipitating with common salt the metallic solutions in nitrous acid, which are susceptible of this precipitation; or, lastly, by decomposing common salt by pure nitrous acid in the operation for making the distilled aqua regia. In all these cases the nitrous acid is evidently combined with marine alkali, and forms cubic nitre. This salt is not used in medicine, chemistry, or the arts, as it is rather inferior than preferable to ordinary nitre.

NITRE FIXED, or ALKALISED BY COALS. To make this extemporaneous alkali, the proper quantity of nitre is to be put into a crucible, which ought to be so large that the nitre shall take up but a small space in it. This crucible is to be placed in a well kindled fire; and when the nitre is melted and red hot, a small spoonful (about a dram or half a dram) of charcoal grossly powdered is to be projected upon it. Instantly a vivid inflammation happens, which continues till all the charcoal is entirely consumed. When this inflammation or detonation ceases, another quantity of charcoal like the former is projected upon it, and is left to be consumed; and thus charcoal is continually to be projected till no more detonation is caused by it.

The matter contained in the crucible, which at first is very fluid, becomes afterwards thick and almost solid, because it is then fixed alkali, which is much less fusible than nitre. The fire must be increased sufficiently to make this alkali melt. During this fusion, some small detonations happen from time to time, which are occasioned by a portion of nitre, which the large quantity of alkali, and the want of fluidity towards the end of the operation, had preserved from the contact of the coals. When the matter is in good fusion, and no detonation happens upon projecting small bits of coals, we may then know that the nitre is alkalisied, and that the operation is finished.

NITRE FIXED BY METALS. All the metallic substances which are susceptible of decomposition being treated in the fire with nitre, alkalisie it, and
make

make it detonate more or less sensibly. The most inflammable of these substances, as zinc and iron, make with this salt so luminous and so brilliant a detonation, that they are advantageously employed for that purpose in fireworks. Other combustible matters are less effectual, but their inflammation with nitre is sufficiently strong to produce all the essential effects of the detonation of nitre : so that after this inflammation, the acid of the salt is decomposed by the combustion of these metals, and its alkali only remains mixed with the earth of the calcined metals.

After the detonation of nitre with metals, its alkali may be easily obtained alone, and separated from the metallic earths, by lixiviating the remainder with water. By filtrating and evaporating this water, this kind of fixed nitre may be obtained in a dry state. It is essentially the same as nitre alkalised by any other inflammable matter, but it is in the caustic state.

NITRE FIXED, OR ALKALISED BY TARTAR. This alkali is made by mixing together equal parts of nitre and tartar, which ought to be only grossly powdered. This mixture is to be put into an open vessel of unvarnished earthen ware, or of iron. It is to be placed under a chimney, and it is to be kindled with a lighted coal. It kindles around the charcoal, and deflagrates at first weakly : but as the matter first inflamed kindles the rest, the detonation increases, a thick smoke rises, and the whole mixture is inflamed. The red and burning matter melts, boils, and flows over the vessel, if this be not sufficiently large : then the detonation gradually diminishes, and at last ceases. The residuum consists of the alkalis of nitre and of tartar mixed together.

This alkali, as well as the nitre fixed by coals, are each of them very pure and good. They are, however, subject to contain a considerable quantity of nitre undecomposed, and of inflammable matter not burnt, particularly when a small quantity only is prepared at once ; but the mass may be completely alkalised by a proper calcination, and by treating it like other fixed alkalis. See **ALKALI (FIXED VEGETABLE)**.

Nitre fixed by tartar is also called white flux, because the most frequent use of this alkali is to facilitate the fusion of ores and metallic matters in essays and similar operations, for which purposes it needs not be perfectly pure. See **FLUX (WHITE)** and **DETONATION OF NITRE**.

NITRES (METALLIC), OR NITRES WITH METALLIC BASES. See the **METALS**.

NITRO-MURIATIC ACID. The compound acid formed by uniting the nitrous and marine acids. It is commonly known by the name of **AQUA REGIA**, which see.

NITROUS ACID. See **ACID NITROUS**.

NITROUS AIR. See **AIR NITROUS**.

NOBLE METALS. This absurd name has been bestowed on the perfect metals, gold, silver, and platina.

NOMENCLATURE. Whenever a new substance or thing comes under our notice we give it a name, and in this denomination we seldom fail to recur to some of the properties or habitudes of the thing. If this were invariably done, and the knowledge of the property or habitude alluded to were perfect, it is evident that a knowledge of the derivation of names would, in almost every instance, convey a large portion of knowledge. On the other hand it is no less evident, that names founded upon mistaken inferences respecting the properties of things, will be received and used as the characteristic marks of those properties, and will greatly

greatly tend to distribute and perpetuate error. Hence the advantages of an accurate nomenclature, especially in the science of matter of fact, which chemistry may be peculiarly termed. Every writer has been more or less sensible of the advantages of accurate denomination. Many have attempted to improve the nomenclature of chemistry, as opportunity offered. Old names have been rejected, and new ones adopted from time to time, and that to such an extent, that the common terms of philosophical chemistry had become considerably remote from those used in pharmacy, till the late reformation of the Dispensatory of the College of Physicians. The nomenclature which has most extensively prevailed among the modern chemical writers of this country, is that of Bergmann. He denominates the five simple earths by the names of calcareous, argillaceous, siliceous, ponderous, and magnesian earths; the alkalis are, fixed vegetable, fixed mineral, and volatile; for the acids, he uses the old denominations, either adjectively, as the nitrous acid, or substantively, as the acid of nitre. The metallic substances are called by their own names, and said to be calcined, or converted into calx, by any of the processes of combustion. In the denomination of compound substances, into which an acid enters, he converts the name of the acid into an adjective, and applies it to the earthy, alkaline, or metallic basis; as in the examples, vitriolated vegetable alkali, nitrated silver, or muriated ponderous earth. He designates the aerial substances by the name of gas.

The French chemists who have rejected the phlogiston, and have shewn the most active zeal in propagating the systematical doctrine, of which the absorption and extrication of vital air, and the composition and decomposition of water, are the leading features, have been particularly attentive to the reformation of chemical nomenclature. Messrs. De Morveau, Lavoisier, Berthollet, and De Fourcroy, published a method of chemical nomenclature at Paris, in the year 1787; and since that time, most of the valuable treatises published in France, or translated into the French language, have followed that enunciation. It appears therefore to be necessary, that every chemist who proposes to make considerable advances in the science, must acquire a knowledge of this chemical language, whether he may be disposed to admit the principles on which it is founded, or the contrary.

In the plan these chemists proposed, simple bodies, viz. such as had not hitherto been decomposed, were entitled in the first place to their attention, because the denomination of substances reduced to their elements by accurate analysis would be naturally determined by uniting the signs of those elements.

These undecomposed substances are divided by them into five classes.

The first class comprehends those principles which, though they do not exhibit any remarkable analogy to each other, have nevertheless this common property, that they appear to approach in an eminent degree to that state of simplicity, which enables them to resist the methods of chemical analysis, at the same time that it renders them highly active in combinations.

In the second class they place all those substances which are capable of being converted into acids. The phlogistian philosophers maintain that this conversion is produced by the expulsion of phlogiston, at the same time that the facts compel them to admit the contemporaneous absorption of vital air. The antiphlogistian philosophers admit only the simple fact of the absorption and combination of vital air, or its basis, with the acidifiable substance, which they consider as undecomposable or simple. Hence they call it the acidifiable basis, or radical principle of the acid. See the respective Acids.

The

The third class comprehends all those substances which can be exhibited under the metallic form. The regulus, or metal itself, is the simple substance. See METALS.

The fourth class comprehends the earths, and

The fifth the alkalis.

At the end of these five classes, they point out, in an appendix, certain substances of a more compounded nature, which combine in the manner of more simple bodies, without undergoing any observable decomposition. It appeared necessary that these bodies should enter into the table of methodical nomenclature, to complete the system.

The substances of the first class are five in number, viz. light, the matter of heat, the air formerly called dephlogisticated air, and afterwards vital air, inflammable air, and phlogisticated air. The latter is placed in their table in the class of acidifiable bases, because it is in fact the basis of the nitrous acid. Chaptal calls it nitrogene, for this reason; but Morveau, in his Memoir, which I chiefly follow in the present account, thinks it requisite from several of its properties to treat of it in this first class.

Light and heat in certain circumstances appear to produce the same effects; but our knowledge not being sufficiently advanced to affirm either their identity or their difference, these nomenclators chose to preserve the distinctive appellation to each; excepting that, as they admit of a material principle which is the cause of the sensation denoted by the word *heat*, they thought fit to give it the name *caloric*. Whenever therefore the word *caloric* is used, it denotes the same thing as the words *matter of heat* imply in the writings of modern philosophers.

The terms *vital air* were rejected, because the property of maintaining light, and the existence of the æriform state, do not accurately designate the substance which enters into combination after giving out heat and light. For since heat and light are considered by these philosophers to be material substances, the vital air will according to them consist of light, heat, and another substance which they call oxygene, a word which denotes the generator of acid.

For similar reasons, they have rejected the terms *inflammable air*, and called the substance formerly so denominated by the name of *hydrogene*, when disengaged from light and heat. This denomination is grounded on its property of composing water when united with oxygene.

The denomination of *phlogisticated air* has been received by chemists in general with dislike, on account of its expressing too strongly a theory at least doubtful. Many have rejected it. From the experiments of Mr. Cavendish it appears well established that this substance enters into the composition of nitrous acid, by combining with vital air; and from the experiments of Berthollet and others it is shewn, that with inflammable air it forms volatile alkali. See ACID NITROUS, AIR ALKALINE, and the articles thence referred to. M. De Fourcroy proposed to call it *alkaligene*; but the nomenclators, considering the analysis not to be sufficiently advanced to ascertain with precision the manner in which this substance enters into the composition of acids and alkalis, preferred the term *azote*, derived from its property of extinguishing animal life.

The second class, containing substances whose principal character is that of passing to the state of acidity, is much more extended. But as it is likewise more uniform in its distinctive attributes, M. De Morveau thought it unnecessary to mention more than a few of those substances in his Memoirs.

In this class it may be observed that some of the acidifiable bases are known,

but that the greater number of acids are such whose constituent parts have not yet been separated. The known acidifiable bases are azote, or the base of nitrous acid; carbone, or that principle which constitutes the greater part of vegetable coal, and is admitted by these chemists, from the experiments of M. Lavoisier, to form the basis of carbonic acid, or fixed air; sulphur, or the basis of vitriolic acid; and phosphorus, or the basis of phosphoric acid. The combinations of these bases are the most numerous, the most familiar, and the most easy to be pursued; for which reasons the French chemists established their nomenclature by attending to them. With regard to the others, such as the bases of the marine acid, the acid of borax, the acid of vinegar, and the like, they were contented merely to denote the simple substance which modifies the oxygene by the expression *acidifiable basis*, or, more concisely, the *radical of the acid*. It is probable, as M. Morveau observes, that many of these acids may have compounded bases; or that their bases may no otherwise differ from each other than in the proportion of the same principles. When analysis shall have discovered these first elements, and the order of their application to each other, it will no doubt be proper to arrange them according to the nomenclature of the other known substances.

M. Morveau accordingly proceeds to explain the nomenclature of the products or combinations which have sulphur for their origin.

Since sulphur, by combining with oxygene, produces an acid, it is evident that the name ought to be derived from the name of the base. But as this acid is exhibited in two states of saturation, in each of which its properties are different, it became necessary to apply a name to each of these states, which, constantly preserving the primitive root, should, nevertheless, mark this difference. It was equally requisite that the same demarcation should follow all the saline compounds of these two acids. Again, it was necessary to attend to sulphur in its other direct combinations, as for example, with earths, alkalis, and metals. Five different terminations, adapted to the same radical word, will distinguish these five states of the same principle.

The *sulphuric* acid will denote sulphur in the utmost degree of saturation with oxygene. It is the vitriolic acid, as commonly denominated.

The *sulphureous* acid will express sulphur united with a smaller proportion of oxygene. It is the volatile sulphureous vitriolic acid, or the phlogisticated vitriolic acid, formerly so called.

Sulphat will be the generic name of all the salts formed by the sulphuric acid.

Sulphite will be the name of the salts formed of the sulphureous acid.

Sulphure will be the name of all the combinations of sulphur not in the state of acidity. In this way one uniform denomination will be substituted instead of the improper and discordant names of liver of sulphur, hepar, pyrites, mat, &c.

From this explanation and the general table annexed, it will be readily seen how the other combinations of the acid bases are arranged and denominated.

The third division of the general table comprehends all the metallic substances at that time known. The uranite or uranium discovered by professor Klaproth, and announced in the year 1790, is therefore not among them. There were cogent reasons not to change the names of those substances. The metallic calces are called oxides. Such as are capable of acidification follow the general rule of other acid bases in their terminations, as may be seen in the articles ARSENIC, MOLYBDENA, and TUNGSTEN. Compounds of metals with metals are called alloys.

The fourth general division comprehends the five well known earths. The combinations

binations of these with the preceding substances have been already spoken of. The three new earths, viz. those obtained from adamantine spar, and the jargon of Ceylon by Mr Klaproth, and that from the mineral analysed by Wedgewood, obtained from New South Wales, are not inserted, as the date of their discovery is subsequent to the formation of this nomenclature.

The three alkalis occupy the fifth and last principal division.

In the appendix of more compounded substances, we find mucus, gluten, sugar, starch, fixed oil, volatile oil, aroma, or the principle of smell in plants and flowers, resin, extract, extracto-resinous matter, refino-extractive matter, fecula, alcohol, the compounds of alcohol, ethers, soaps.

It will be observed in the table, that it is divided into six vertical double columns, under the title of 1. Substances not decomposed. 2. Converted into the state of gas by caloric. 3. Combined with oxygene. 4. Gaseous oxygenated. 5. Oxygenated with bases. 6. Combined without being converted into the acid state. These columns are double, in order that the first compartment may contain the new name, and the second the correspondent old name. Every horizontal division exhibits the different states and compounds of the simple substance which is at its head or commencement.

T A B L E O F T H E

Proposed by Messrs. De Morveau, Lavoisier,

	I. SUBSTANCES NOT DECOMPOSED.		II. CONVERTED INTO THE STATE OF GAS BY CALORIC.		III. COMBINED WITH OXYGENE.	
	NEW NAMES.	ANCIENT NAMES.	NEW NAMES.	ANCIENT NAMES.	NEW NAMES.	ANCIENT NAMES.
1	Light.					
2	Caloric.	<i>Latent heat, or the matter of heat.</i>				
3	Oxygen.	<i>Base of vital air.</i>	Oxygenous gas. <i>N.B. It appears that light assists to change it into the state of gas.</i>	<i>Dephlogisticated air, or vital air.</i>		
4	Hydrogen.	<i>Base of inflammable gas.</i>	Hydrogenous gas.	<i>Inflammable gas.</i>	Water.	<i>Water.</i>
5	Azote, or the Nitric radical.	<i>Base of phlogisticated air, or of the atmospherical meset.</i>	Azotic gas.	<i>Phlogisticated air, or atmospherical nephitis.</i>	Base of nitrous gas. Nitric acid. <i>And with excess of azot, Nitrous acid.</i>	<i>Base of nitrous gas. Colourless nitrous acid. Fuming nitrous acid.</i>
6	Carbon, or the Carbonic radical.	<i>Pure charcoal.</i>			Carbonic acid.	<i>Fixed air, or cretaceous acid.</i>
7	Sulphur, or the Sulphuric radical.				Sulphuric acid.	<i>Vitriolic acid.</i>
8	Phosphorus, or the Phosphoric radical.				<i>And with less oxygen, Sulphureous acid.</i>	<i>Sulphureous acid.</i>
9	Muriatic radical.				Phosphoric acid. <i>And with less oxygen, Phosphorous acid.</i>	<i>Phosphoric acid. Fuming, or volatile phosphoric acid.</i>
10	Boracic Radical.				Muriatic acid. <i>And with excess of oxygen, Oxygenated muriatic acid.</i>	<i>Marine acid. Dephlogisticated marine acid.</i>
11	Fluoric radical.				Boracic acid.	<i>Sedative salt.</i>
12	Succinic radical.				Fluoric acid.	<i>Acid of spar.</i>
13	Acetic radical.				Succinic acid.	<i>Volatile salt of amber.</i>
14	Tartaric radical.				Acetous acid. <i>And with more oxygen, Acetic acid.</i>	<i>Distilled vinegar. Radical vinegar.</i>
15	Pyro-tartaric radical.				Tartareous acid.	
16	Oxalic radical.				Pyro-tartareous acid.	<i>Empyreumatic tartareous acid, or spirit of tartar.</i>
					Oxalic acid.	<i>Saccharine acid.</i>

ACIDIFIABLE BASES.

IV. OUS OXYGENATED.		V. OXYGENATED WITH BASES.		VI. COMBINED WITHOUT BEING CON- VERTED INTO THE ACID STATE.	
AMES.	AN IENT NAMES.	NEW NAMES.	ANCIENT NAMES.	NEW NAMES.	ANCIENT NAMES.
		Nitrate of potash. Nitrate of soda, &c.	Common nitre. Cubic nitre.		
		Nitrite of potash.			
as.		Carbonate { of lime. of potash, &c. of iron.	Chalk. Aerate alkalies. Rust of iron.	Carbure of iron.	Plumbago.
gas.	Fixed air, mephitic air.	Sulphate { of potash. of soda. of lime. of alumine. of barytes. of iron, &c.	Vitrified tartar. Glauber's salt. Selenite. Alum. Pondrous spar. Vitriol of iron.	Sulphure { of iron. of antimony. of lead, &c. Sulphurated hydrogenous gas. Sulphure of potash. Sulphure of soda, &c. } Alkaline sulphures contain- ing metals. Alkaline sulphures contain- ing charcoal.	Facitious pyrites of iron. Antimony. Hepatic gas. Alkaline livers of sulphur. Metallic liver of sulphur. Liver of sulphur containing charcoal.
id gas.	Sulphureous acid gas.	Sulphite of potash, &c.	Stahl's sulphureous salt.		
		Phosphate { of soda. of lime, &c.	Phosphoric salt with base of natrum. Earth of bones.		
		Phosphat super-saturated with soda. Phosphite of potash, &c.	Thaipi's pearly salt.	Phosphorized hydrogenous Phosphure of iron.	[gas. Phosphoric gas. Syderite.
gas.	Marine acid gas.	Muriate { of potash. of soda. of lime, &c. of ammoniac.	Fehrsunge salt of Sylvius. Sea-salt. Calcareous fra. salt. Sal ammoniac.		
uriatic acid	Dephlogistified marine acid gas.	Oxygenated muriate of soda, &c.	Common borax.		
		Borat super-saturate { with foda, or borax. Borate of soda, &c. the soda saturated with acid.			
as.	Sulphuric acid gas.	Fluate of lime, &c. Succinate of soda, &c.	Fluor spar.		
		Acetate { of potash. of soda. of lime. of ammoniac. of lead. of copper.	Terra foliata tartari. Mineral foliated tartar. Calcareous acetons salt. Mendeleev's spirit. Sage of lead. V'a degrass.		
		Acetate of soda, &c.			
		Acidulous tartrate of potash. Tartrate of potash. Tartrate of soda, &c.	Cream of tartar. Vegetable salt. Salt of Seignette.		
		Pyro-tartrate of lime. Pyro-tartrate of iron, &c.			
		Acidulous oxalate of potash. Oxalat of lime. of soda, &c.	Salt of fowls.		

	I. SUBSTANCES NOT DECOMPOSED.		II. CONVERTED INTO THE STATE OF GAS BY CALORIC.		III. COMBINED WITH OXYGENE.	
	NEW NAMES.	ANCIENT NAMES.	NEW NAMES.	ANCIENT NAMES.	NEW NAMES.	ANCIENT NAMES.
17	Gallie radical.				Gallie acid.	<i>Astringent principle.</i>
18	Citric radical.				Citric acid.	<i>Lemon-juice.</i>
19	Malic radical.				Malic acid.	<i>Juice of apples.</i>
20	Benzoic radical.				Benzoic acid.	<i>Flowers of benzoïn.</i>
21	Pyro-lignic radical.				Pyro-ligneous acid.	<i>Spirit of box.</i>
22	Pyro-mucic radical.				Pyro-mucous acid.	<i>Spirit of honey, of figs &c.</i>
23	Camphoric radical.				Camphoric acid.	
24	Lactic radical.				Lactic acid.	<i>Acid of milk.</i>
25	Saccho-lactic radical.				Saccho-lactic acid.	<i>Acid of the sugar of milk.</i>
26	Formic radical.				Formic acid.	<i>Acid of ants.</i>
27	Prussic radical.				Prussic acid.	<i>Colouring matter of Prussia blue.</i>
28	Sebacic radical.				Sebacic acid.	<i>Acid of fat.</i>
29	Lithic radical.				Lithic acid.	<i>Acid of the stone of uric acid.</i>
30	Rombic radical.				Rombic acid.	<i>Acid of rhubarb.</i>
31	Arsenic.	<i>Regulus of arsenic.</i>			Oxide of arsenic.	<i>White arsenic, or calc of arsenic.</i>
32	Molybdena.				And with more oxygene, Arsenic acid.	<i>Arsenic acid.</i>
33	Tungstein.				Oxide of molybdena.	<i>Calx of molybdena.</i>
34	Manganese.	<i>Regulus of manganese.</i>			Molybdic acid.	
35	Nickel.				Oxide of tungstein.	<i>Yellow calx of tungstein.</i>
36	Cobalt.	<i>Regulus of cobalt.</i>			Tungstic acid.	
37	Bismuth.				White } Oxide of man- Black } ganese. Vitreous }	<i>Manganese.</i>
38	Antimony.	<i>Regulus of antimony.</i>			Oxide of nickel.	<i>Calx of nickel.</i>
39	Zink.				Grey oxide of cobalt.	<i>Calx of cobalt.</i>
40	Iron.				Vitreous oxide of cobalt.	
41	Tin.				White } Oxide of bismuth Yellow } Vitreous }	<i>Weight 1, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100.</i>
42	Lead.				White oxide of antimony } by the nitrous acid. of antimony } by the muriatic acid.	<i>Diaphoretic antimony.</i>
43	Copper.				White sublimated oxide of antimony.	<i>Powder of algaroth.</i>
44	Mercury.				Vitreous oxide of antimony.	<i>Flowers or snow of antimony.</i>
45	Silver.				Oxide of zink.	<i>Glass of regulus of antimony.</i>
46	Platina.				Sublimated oxide of zink.	<i>Calx of zink.</i>
47					Black oxide of iron.	<i>Flowers of zink. Pentoxide, &c.</i>
					R. A oxide of iron.	
					White oxide of tin.	<i>Calx of iron.</i>
					White oxide of lead.	<i>Calx of tin.</i>
					Yellow oxide of lead.	<i>Calx of lead.</i>
					Red oxide of lead.	<i>Calx of lead.</i>
					Vitreous oxide of lead.	<i>Calx of lead.</i>
					Green oxide of copper.	<i>Calx of copper.</i>
					Blue oxide of copper.	<i>Calx of copper.</i>
					Blackish } Mercurial oxide. Yellow } Red }	<i>Calx of mercury.</i>
					Oxide of silver.	<i>Calx of silver.</i>
					Oxide of platina.	<i>Calx of platina.</i>
					Oxide of gold.	<i>Calx of gold.</i>

IV.		V.		VI.	
ACIDOUS OXYGENATED.		OXYGENATED WITH BASES.		COMBINED WITHOUT BEING CONVERTED INTO THE ACID STATE.	
NEW NAMES.	ANCIENT NAMES.	NEW NAMES.	ANCIENT NAMES.	NEW NAMES.	ANCIENT NAMES.
		Gallate ^{of soda.} of magnesia. of iron.			
		Citrate of potash.	<i>Polished earth with lemon juice.</i>		
		Citrate of lead, &c.			
		Malate of lime, &c.			
		Aluminous benzoate.			
		Benzoate of iron, &c.			
		Pyro-lignite of lime.			
		Pyro-lignite of zinc.			
		Pyro-mucite of magnesia.			
		Ammoniacal pyro-mucite, &c.			
		Camphorate of soda, &c.			
		Lactate of lime, &c.			
		Saccholate of iron, &c.			
		Ammoniacal formate, &c.	<i>Spirit of magnanimity.</i>		
		Prussiate of potash, &c.	<i>Polygluticated alkali, or Prussian alkali.</i>		
		Prussiate of iron, &c.	<i>Prussian blue.</i>		
		Sebate of lime, &c.			
		Lithiate of soda, &c.			
		Bombsite of iron, &c.			
WITH DIFFERENT BASES.*					
phurated	<i>Orpiment.</i>	Arseniate of potash, &c.	<i>Macquer's arsenical neutral salt.</i>	Alloy of arsenic and tin.	<i>Arsenicated tin.</i>
de of anti-	<i>Realgar.</i>	Arseniate of copper, &c.			
de of potash	<i>Liver of arsenic.</i>	Antimoniate.		Alloy, &c.	
glyden.	<i>Molybdena.</i>				
		Calcareous tungstate.	<i>Tungsten of the Swedes.</i>	Alloy, &c.	
				Alloy of manganese and iron.	
				Alloy of nickel, &c.	
				Alloy, &c.	
nic oxides.	<i>Precipitates of cobalt redissolved by alkalis.</i>				
oxide of bismuth	<i>Bismuth precipitated by liver of sulphur.</i>			Alloy, &c.	
phurated	<i>Gray calx of antimony.</i>				
de of anti-	<i>Kermes mineral.</i>			Alloy, &c.	
de of anti-	<i>Golden sulphur of antimony.</i>				
	<i>Glauber's liver of antimony.</i>				
ide of zinc.	<i>Precipitate of zinc by liver of sulphur.</i>			Alloy, &c.	
ide of iron.				Alloy, &c.	
oxide of tin	<i>Arsenic impure.</i>			Alloy, &c.	
ide of lead.				Alloy, &c.	
ide of copper.				Alloy, &c.	
rated oxide of mercury.	<i>Elk's mineral.</i>			Alloy or amalgam of, &c.	
	<i>Concolor.</i>			Alloy, &c.	
ool silver				Alloy of platinum and gold.	
				Alloy, &c.	

Substances placed in the interior part of this column cannot be changed into the state of gas as well as many of those that are above the line, and by many of that which we have substituted we express certain combinations of metals.—Note by the Author.

I. SUBSTANCES NOT DECOMPOSED.		II. CONVERTED INTO THE STATE OF GAS BY CALORIC.		III. COMBINED WITH OXYGENE.	
NEW NAMES.	ANCIENT NAMES.	NEW NAMES.	ANCIENT NAMES.	NEW NAMES.	ANCIENT NAMES.
48 Silx.	<i>Vitrifiable earth, quartz. &c.</i>				
49 Alumine.	<i>Argillaceous earth, or earth of alum.</i>				
50 Barytes.	<i>Barytes, ponderous earth.</i>				
51 Lime.	<i>Calcareous earth.</i>				
52 Magnesia.					
53 Potash.	<i>Vegetable fixed alkali, salt of tartar. &c.</i>				
54 Soda.	<i>Mineral alkali. Marine alkali. Natrium.</i>				
55 Ammoniac.	<i>Fluor, or caustic volatile alkali.</i>	Ammoniacal gas.	Alkaline gas.		

NAMES GIVEN TO SEVERAL MORE COMPOUND SUBSTANCES

NEW NAMES.	1	2	3	4	5	6	7	8	9	10
	Mucus.	Gluten.	Sugar.	Starch.	Fixed oil.	Volatile oil.	Aroma.	Refin.	Extract.	Extraflo-resinous matter, when the extract predominates.
ANCIENT NAMES.	Mucilage.	Glutinous matter.	Saccharine matter.	Amylaceous matter.	Unctuous, or fat oil.	Essential oil.	Spiritus rectior.	Refin.	Extractive matter.	

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12	13	14	15	16	17
Fecula.	Alcohol, or Spirit of wine.	Alcohol of potash. of guaiacum. of scammony. of myrrh, &c.	Nitrous alcohol. Gallic alcohol. Muriatic alcohol.	Sulphuric ether. Muriatic ether. Acetic ether, &c.	Alkaline soaps. Earthy soaps. Acid soaps. Metallic soaps. Saponul of turp. &c.
Fecula.	Spirit of wine.	Alkaline tincture. of guaiacum. of scammony. of myrrh, &c.	Dulcified spirit of wine. Tincture of gall. Dulcified marine acid.	Frobenius's ether. Marine ether. Acetous ether, &c.	Alkaline soaps. Earthy soaps, &c. Combinations of the volatile oils with different bases.

NORKA. A compound stone of the filiceous genus, being a variety of the granite or moor-stone. It is either grey or reddish, and consists of quartz, garnet, and mica. It is used for mill-stones.

NUTMEGS. This fruit contains two kinds of oils, namely, a gross sebaceous oil, and a volatile essential fluid oil; in which last the peculiar taste and smell of nutmegs reside. The essential oil also appears to be of two kinds; one of which is so light as to swim upon water, and to rise in distillation with spirit of wine; and the other is so gross and ponderous, that it sinks in water, and is with difficulty capable of being distilled with water, and not at all with spirit of wine.

Sixteen ounces of nutmegs yielded, by distillation, half an ounce of essential oil; and afterwards four or five ounces of the gross sebaceous oil were found floating on the surface of the water in the still. Rectified spirit of wine dissolves all the essential oil, and a part of the expressible oil. From four ounces of nutmegs nine drams of a concrete oil were expressed. This oil contains a considerable portion of the essential oil. It is brought from India in form of cakes, and is called oil of mace, the mace being one of the exterior coverings of the nutmeg, and containing similar oils. Neumann.

NUX VOMICA, so called, is not a nut, but the seed of a fruit like an orange, growing in the East Indies: it is called by the Germans *krähenaugen*, crows'-eyes, from its having somewhat of the appearance of a grey eye, and from its being poisonous to crows. The tree is described and figured in the *Hortus Malabaricus*, under the name of *Caniram*. The seeds brought to us are of different sizes, and produced by different species of the plant. The tree which yields the smaller sort is that whose roots are the *lignum colubrinum* of the shops. They are commonly of a roundish flat figure, variously bent, with a navel or prominence in the middle covered all over with fine short hairs like velvet; the kernel is nearly of the consistence of horn, but harder and more brittle, so as to be beat in pieces by a hammer.

An ounce of nux vomica, rasped into fine powder, yielded with water half an ounce of gummy extract, and afterwards with spirit only five grains of resin; another ounce, treated first with spirit, gave one dram 32 grains of resinous extract, and afterwards two drams 36 grains of mucilage; the insoluble part amounting to about half the weight of the seed. Both the watery and spirituous extracts, prepared at first, are very bitter, particularly the spirituous: those made by either menstruum, after the other has performed its office, have little bitterness. In distillation neither water nor spirit brings over any thing remarkable. The watery spirit of sal ammoniac digested on this seed, gains a deeper colour than any other menstruum; the tincture is brownish red. The vinous spirit of sal-ammoniac scarcely extracts a yellowish hue; and simple spirit of wine receives no tinge at all.

Nux vomica is poisonous to dogs, to other carnivorous animals and such as are born blind. It does not indeed follow, from hence, that it is poisonous to men; and some have even recommended it as a notable diaphoretic and alexipharmic; and Melichius observes that it is eaten by the Turks without injury. But Seutter tells us of a woman in Holland, who, on taking a dose of nux vomica, mixed with a little gentian, for the cure of an intermitting fever, was thrown into violent convulsions, from which she difficultly escaped with her life: this one example is sufficient to deter us from the use of the nux vomica, especially as we are furnished with efficacious and unsuspected medicines for all the intentions in which it is recommended. It is observable, that the outer skin, and its hairy covering, are more virulent than the kernel. Neumann.

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OAK. The uses of the wood of the oak tree are sufficiently known. Every part of this vegetable abounds with astringent matter; but the substances more particularly attended to by chemists are, the excrecence of the oak, called the nut gall, of which we have already treated under the articles *ACID OF GALLS*, and *INK*; and the bark of the tree, used in the process of tanning, which see.

OCHRE. A ferruginous earth, or ore of iron, commonly of a yellow, brown, or red colour. It is used as a pigment. The colour of such specimens as are dark, may be rendered of a brighter red by calcination; which alters the state of the metal. Ochres appear to have been produced by the decomposition of the martial pyrites, which consist of sulphur and iron. By the combined action of the air and water, the sulphur becomes acidified, and forms vitriol, the iron of which may be deposited upon calcareous earths, which seize the acid: or more commonly, by the more complete calcination of the iron, by the air, which then becomes less soluble and falls down, as is seen in a solution of common vitriol left in an open vessel. In many places the iron is extracted from this ore.

OCULUS MUNDI. See *HYDROPHANES*.

ODOUR. See *SMELL*, *PRINCIPLE OF*.

OFFA ALBA, or OFFA HELMONTII. When strong ardent spirit is added to a solution of mild volatile alkali in water, the salt is precipitated in consequence of the strong attraction of the spirit for the water. No such precipitation takes place when the alkali is caustic, because the pure alkali is itself soluble in the spirit, whether it be exhibited in the form of air, or the aqueous solution.

OIL. The distinctive characters of oil are, inflammability, insolubility in water, and fluidity, at least in a moderate temperature. They are distinguished into fixed oils, or fat oils, which do not rise in distillation at the temperature of boiling water, and volatile or essential oils, which do rise at that temperature.

Fixed oils are obtained by pressure from the emulsive seeds or kernels of vegetables; they are generally fluid in the temperature of the atmosphere, but some of them have a considerable degree of firmness or solidity. They have a very smooth feel; are mostly without smell or taste; require a degree of heat much superior to that of boiling water, to cause them to rise in ebullition; and cannot be set on fire, unless heated to this degree. The use of the wick of a lamp consists in bringing small portions of oil to its extremity, by the capillary attraction; where they become successively volatilized and inflamed. Oils are remarkably less sonorous than water, when poured out. Fat oils, not being at all dissipated by the heat of the atmosphere, make a permanent greasy spot when they fall on porous substances.

These oils are decomposed by distillation, and afford a small quantity of water loaded with a peculiar acid, a light oil, a dense oil, inflammable air, and fixed air. The residue consists of a small quantity of charcoal.

In the last analysis of organized substances the results are, inflammable air, vital air, phlogisticated or azotic air, and fixed air, or pure coal, which appears to be its basis. By what combinations or super-compositions they are made to exhibit

the variety of products which come under our observation, can in few respects be ascertained by any experiments we are yet capable of making. Lavoisier, in the Memoirs of the French Academy for 1784, collected the products of olive oil burned in an apparatus properly constructed to ascertain their nature and properties. He obtained 79 parts of carbone, and 21 of hydrogene, from 100 of the oil. From these component parts, inferences may be formed respecting the acid, the water, the fixed air, and the inflammable air, afforded by the partial decompositions, or combustions of this fluid.

The light oil produced by distillation of fat oils, is naturally more disposed to fly off by heat, and leaves less coal behind it, than the fat oil itself. This property renders it useful in some of the arts, as those of lapidaries, seal-engravers, and others, who grind precious stones with fretting powders. The oil used for this purpose is known by the name of oil of bricks, and is made, as I am informed, by igniting pieces of brick, quenching them in olive oil, and afterwards distilling the oil from the pieces of brick which had imbibed it. In order to form a proper notion of the advantage of this fluid, it must be remarked, that all grinding produces heat; that this heat would speedily evaporate water, and render common oil thick; that, if neither water nor oil were present, the heat would very soon increase to strong ignition, and injure both the tool and the substance operated on. The oil of bricks possesses neither of the bad qualities of the two fluids here mentioned, in so considerable a degree, and is therefore preferred for such work as can afford the expence.

Fat oils, by exposure to the air, become rancid, and exhibit a disengaged acid, which may be washed off by water. When they are exposed to the air, in a thin coat, upon the surface of water; they become more consistent, like wax, by absorbing the vital part of the atmosphere. The aerated or dephlogisticated marine acid produces this change more speedily. Agitation in water separates a mucilage from them. They combine with magnesia, and with lime, which convert them into saponaceous compounds. With the pure alkalis they form common soap. They do not unite with the volatile alkali, but by long trituration.

The mineral acids unite with fat oils, and form compounds, or imperfect soaps. Fuming nitrous acid causes them to take fire, as has already been observed. Sulphur is soluble in fat oils, by a digesting heat; and is gradually deposited in part from them, in a crystalline form, by cooling.

These sulphureous compounds are called balsams of sulphur.

Fixed oils seem not to be susceptible of combination with pure metallic substances, excepting iron and copper, upon which they act in a sufficiently distinct manner. But they combine with metallic calces, and form with them thick concrete combinations, of a soapy appearance, as is observable in the preparation of unguents and plasters. These preparations have not been yet chemically examined: only we know, that some metallic calces are reduced in the making up of plasters; as for instance, the calx of copper in the Divine Plaster, and litharge, or calx of lead, in the Ointment *de la Mere*. In the assaying of metals, fixed oils are employed to reduce the metallic calces. M. Berthollet has given an ingenious and simple process for effecting instantaneously a real combination between fixed oil and any metallic calx, that is, for preparing a metallic soap. It consists in pouring a metallic solution into a solution of common soap. The acid of the metallic solution combines with the fixed alkali of the soap; and the metallic calx is then precipitated in union with the oil, to which it communicates a colour. In this manner, soap of a beautiful green colour may be prepared

with vitriol of copper; and with vitriol of iron, a clear deep brown soap. Fourcroy thinks these compounds might be very useful in painting.

Scheele has discovered, that when oil of sweet almonds, olives, rape-seed, or lint-seed, is combined with calx of lead, with the addition of a little water, there is a matter separated from the oil which swims on the surface of the liquor, and to which he has given the name of the mild principle. On evaporating this supernatant water, the principle dissolved in it causes it to take the consistency of syrup: when exposed to a strong heat, it takes fire: one part is volatilized in distillation, without burning: the coal which it leaves is light: it does not crystallize; nor does it seem to be susceptible of fermentation. Nitrous acid, distilled on this matter four times successively, changes it into acid of fugar. This mild principle of Scheele's appears to be a sort of mucilage.

The dense animal oils, such as butter, tallow, fat, the oil of the whale, and the like, exceedingly resemble vegetable fixed oils. They appear, however, to contain a proportion of azotic air, or animalized matter, probably in the state of ferum or jelly. The volatile oil obtained by attenuating animal oil, by a number of successive distillations, is called the oil of Dippel. Macquer observes, that it may be rendered almost as white, thin, and volatile, as ether, and is then capable of acting upon the brain and nervous system, in a dose of from four to ten or twelve drops, incorporated with some proper vehicle.

It is much more difficult to obtain this oil in a pure state from fixed oils, than from gelatinous matters, of which hartshorn is to be preferred. It is necessary to change the vessels at each successive distillation, or else to clean them perfectly, because a very small part of the thicker and less volatile oil is sufficient to spoil a large quantity of that which is more highly rectified. Beaumé has observed, that this operation may be greatly abridged by taking care to receive none but the most volatile part in each distillation, and to leave a large residuum, which is to be neglected, and only the more volatile part is to be further rectified. By this method, we may obtain in three or four distillations a considerable quantity of fine oil of Dippel, which could not be obtained after 50 or 60 distillations, without attending to this circumstance. And Monnet asserts, that, by mixing acids with animal oil, their rectification may be very much facilitated.

The oil of Dippel must be kept in clean glass bottles with ground stoppers, and exposed as little as possible to the air, because its volatile parts fly off, and the remainder becomes coloured.

Fourcroy distinguishes vegetable fat oils into three classes. In the first, he places such as are congealable by cold, thicken very slowly by exposure to air, form soaps with acids, and require an addition of vitriolic acid to that of nitre in order to inflame them. Such are,

1. Oil of olives, obtained by bruising that fruit between two mill-stones, and pressing it in bags made of rushes. That which runs first is called virgin oil; that which is obtained from mark sprinkled with water is not so pure, and deposits a lee; that obtained from unripe olives is the *oleum amphacinum* of the ancients. Oil of olives freezes at 10° under zero, in Reaumur's thermometer, or 10½° above that point in Fahrenheit's, and will stand about twelve years without becoming rancid.

2. Oil of sweet almonds, extracted without the application of heat, becomes very soon rancid; it freezes at 6° under 0 in Reaumur's scale, or 17½° of Fahrenheit's.

3. Oil of rape-seed, obtained from the seed of a kind of cabbage, called colza.

4. Oil

4. Oil of ben, extracted from the ben nut of Egypt and Arabia ; it is very acrid, and destitute of smell ; it freezes very easily.

The second class comprehends oils subject to become dry, which are very easily rendered thick, are not fixed by the action of cold, are kindled by the nitrous acid, and form with vitriolic acid a sort of resin. Such are,

1. Lint-feed oil, obtained by pressure from lint-feed ; it is used for oily varnishes, and in painting.

2. Oil of nuts, applied to the same uses.

3. Oil of carnations, or poppy-feed ; which, as has been fully proved by the Abbé Rozier, is not at all narcotic.

4. Oil of hemp-feed, which is very drying.

Under the third genus, he comprehends concrete fixed oils, or vegetable butters ; among which may be distinguished the following :

1. Butter of cacao, extracted from the cacao nut.—There are four sorts of cacao ; the large and the small caracca, the berbice, and that of the islands : this butter is extracted from the nut by roasting, and subsequent boiling in water ; it is purified by melting it by a very moderate heat.

2. The cocoa nut affords a similar butter.

3. Vegetable wax is of the same nature, only more solid. It is the production of China ; it is there made into yellow, white, or green candles, the colour varying with the manner in which the wax is extracted. The catkins of birch and poplar afford a small quantity of a similar wax ; that of Louisiana is more plentiful. M. Berthollet easily whitens it with oxygenated muriatic acid.

Volatile or essential oils have usually a strong aromatic smell, are sufficiently volatile to rise with the heat of boiling water, and are in general soluble in spirit of wine. They exist in almost all fragrant vegetables ; and in the various plants which supply them they are found either in the wood, the root, the bark, the leaves, the flowers, the fruits, &c. They differ very much in the degree of fluidity they possess at a common temperature, and their colours are various. They are obtained either by expression, as from the peel of oranges and lemons, or by distillation with water. Some essential oils, such as those of cinnamon, saffra, and other foreign plants, sink to the bottom of the water with which they come over ; others float at the top. It is easy to distinguish the adulteration of volatile oils, either by pouring ardent spirit upon them, which will not dissolve the fat oil they may be contaminated with ; or if they be dropped on paper, and held to the fire, in this case they leave a greasy spot behind. If oil of turpentine be fraudulently added to them, its smell betrays its presence when treated in this manner.

Volatile oils are very inflammable ; by exposure to air they become thick in process of time, and assume the character of resins.

They unite with difficulty to lime and alkalis. The vitriolic acid converts them into bitumens ; but, if diluted, it renders them saponaceous, as does likewise the muriatic acid. Nitrous acid inflames them.

They unite very readily with sulphur, and form balsams. Mucilages and sugar render them soluble or diffusible in water.

These oils not only contain all the smell, but sometimes likewise the taste of the body from which they have been extracted ; in consequence of which the residuum has lost these sensible qualities. There are indeed several vegetables that have an agreeable flavour, and notwithstanding yield no ethereal oil on being distilled with water, of which lilies, hyacinths, clove, july-flowers, violets, the bloom of the lime or linden-tree, lilies of the valley, &c. are usually adduced as instances ;

instances; a fact which might be opposed to what has been asserted just above. But this objection in the opinion of Wiegleb is easily overturned, as he thinks he is able to prove, that the reason why none of these substances yield ethereal oil, is only because they contain but a small, though a strong-scented portion of this oil, which is imbibed by the water employed in the distillation; in consequence of which, this likewise acquires the same smell as was originally possessed by the vegetable itself. Roses, orange-flowers, and several other similar substances, which contain but very little oil, were formerly ranked among these, as they also yield no oil, when in small quantities; but it is now certainly known, that in large quantities they afford a small portion of oil. We find likewise that vegetables, which are certainly known to contain volatile oil, when distilled in small quantities, yield an odorous distilled water only, in which frequently not the least vestige of such oil is discoverable. Wiegleb very rationally supposes that, if those vegetables which produce an odorous water were submitted to distillation by the hundred weight, they would yield an ethereal oil just as well as the others; and that we should necessarily be convinced, that the whole of their smell is derived from a small quantity of a strong-scented ethereal oil.

The presence of essential oils is discoverable by the smell. In these they are commonly in appropriated vessels, which, however, are sometimes so small that they cannot be distinguished by the naked eye, yet in some they may be observed by the assistance of microscopes; as for instance, in nutmeg, angelica, and master-wort, juniper-berries, lemon and orange-peel. From these two last the Italians are accustomed to separate the oil by expression, by which means they preserve their natural agreeable odour and taste.

Essential oils are found in very different proportions in the substances which contain them. It is scarcely practicable to determine with accuracy the quantity of oil yielded by each substance; but it is a very desirable thing even to know the proportions of them nearly. In this view, the following table from Wiegleb may be of use, which at least will furnish much information to such as may wish to prosecute the subject.

TABLE exhibiting the Quantity of ETHEREAL OIL obtained from different VEGETABLES.

Name of the Vegetable.	Quantity.	Weight of the Oil.	Maker of the Experiment.
AGALLOCHUM wood	— 10 lb	4 drachms	Hoffmann
Angelica root	— 1 lb	1 drachm	Cartheuser
Aniseed	— 1 lb	2 drachms	Neumann
Assafoetida	— 4 ounces	1 drachm	Ditto
Balm, common	— 6 baskets	1 drachm	} Dehne
— Turkey	— ditto	2 ounces	
Cajaput seeds	— 1 lb	15 grains	Dehne
Calamus aromaticus	— 50 lb	2 ounces	Hoffmann
—	— 1 lb	2 scruples	Neumann
Camomile flowers, common	— 1 lb	$\frac{1}{2}$ drachm	Cartheuser
—	— 6 lb	5 drachms	Lewis
—	— 200 baskets	1 lb	Dehne

Camomile

Name of the Vegetable.	Quantity.	Weight of the Oil.	Maker of the Experiment.
Camomile flowers, wild	1 lb	20 grains	Cartheuser
	6 lb	2½ drachms	Lewis
— Roman	30 lb	1¾ ounces	Dehne
Caraway seeds	4 lb	2 ounces	} Lewis
	2 lb	9 drachms	
	1 cwt	83 ounces	
Cardamum seeds	1 ounce	1 scruple	Neumann
Cariophylli Plinii	½ lb	½ ounce	Dehne
Carlisle thistle root	1 lb	2½ scruples	Neumann
Carrot seeds	2 lb	1½ drachm	Lewis
Cascarilla bark	1 lb	1 drachm	Cartheuser
	30 lb	4 ounces	Dehne
Cassia flores	1 lb	¼ drachm	Cartheuser
	30 lb	4 ounces	Dehne
Cedar wood	1 lb	2 drachms	Margraff
Chervil leaves	9 lb	½ drachm	Neumann
Cinnamon	1 lb	1 drachm	Sala
	1 lb	2½ scruples	Neumann
	4 lb	6 drachms	Lemeri
	1 lb	2 drachms	Cartheuser
	1 lb	8 scruples	Ditto
	3 lb	4 drachms	Dehne
Clary (garden), the seeds	4 lb	2 drachms	} Lewis
— in flower, fresh	130 lb	3½ ounces	
Cloves	1 lb	1½ ounce	Teichmeyer
	1 lb	2¼ ounces	Cartheuser
	2 lb	5 ounces	Hoffmann
	2 lb	5 ounces	
	1 lb	1 oz 6 drach.	} Dehne
	1 lb	2½ ounces	
	1 lb	2 oz 2 drach.	
Copaiba balsam	1 lb	6 ounces	Hoffmann
	1 lb	8 ounces	Lewis
Culilabani cortex	1 lb	1 drachm	Vogel
Cumin seed	1 lb	5 drachms	Ditto
	1 bushel	21 ounces	Lewis
Dill seed	4 lb	2 ounces	Ditto
— with the tops	6 baskets	8 ounces	Dehne
Dittany of Crete	1 lb	30 grains	Lewis
Elecampane root	2 lb	3½ scruples	Neumann
— dry	12 lb	3½ drachms	Dehne
Elemi (gum)	1 lb	1 ounce	Neumann
Fennel seed (common)	1 lb	8 scruples	Ditto
— sweet	1 bushel	18 ounces	Lewis
Feverfew flowers	1 basket	2 drachms	Dehne
Galangal root	1 lb	1 drachm	Cartheuser
Garlic root, fresh	2 lb	30 grains	Neumann
Ginger	1 lb	1 drachm	Ditto
Horie-radish root	1 lb	15 grains	Vogel

Name of the Vegetable.	Quantity.	Weight of the Oil.	Maker of the Experiment.
Horie-radith root	8 ounces	15 grains	Neumann
Hyssop leaves	2 lb	1 $\frac{1}{2}$ drachm	Ditto
	1 lb	ditto	Cartheufer
	1 lb	2 drachms	Ditto
	2 cwt	6 ounces	} Lewis
	10 lb	3 drachms	
	30 lb	9 drachms	
Juniper berries	8 lb	3 ounces	Hoffmann
	1 lb	3 drachms	Cartheufer
	48 lb	6 ounces	} Dehne
	60 lb	6 $\frac{1}{2}$ ounces	
wood	15 lb	2 ounces	
Lavender, in flower, fresh	48 lb	12 ounces	} Lewis
	30 lb	6 $\frac{1}{2}$ ounces	
	13 $\frac{1}{2}$ cwt	60 ounces	
	2 lb	4 drachms	Hoffmann
dry	4 lb	2 ounces	Lewis
	2 lb	1 ounce	} Hoffmann
	4 lb	3 ounces	
broad-leaved, dry	4 lb	1 ounce	
	1 lb	1 drachm	Cartheufer
Lovage root	1 lb	1 drachm	Ditto
Mace	1 lb	5 drachms	Neumann
Marjoram in flower, fresh	85 lb	3 $\frac{1}{2}$ ounces	} Lewis
	13 $\frac{1}{2}$ lb	3 $\frac{1}{2}$ drachms	
	34 lb	1 $\frac{1}{2}$ ounce	
leaves, fresh	18 $\frac{1}{2}$ lb	$\frac{1}{2}$ ounce	} Hoffmann
dry	4 lb	1 ounce	
	1 lb	$\frac{1}{2}$ drachm	Neumann
Masterwort root	1 lb	$\frac{1}{2}$ drachm	Dehne
Milfoil flowers	18 baskets	4 $\frac{1}{2}$ ounces	Lewis
dry	14 lb	4 drachms	Ditto
Mint in flowers, fresh	6 lb	4 $\frac{1}{2}$ drachms	Hoffmann
leaves, dry	4 lb	1 $\frac{1}{2}$ ounce	Dehne
fresh	30 baskets	1 $\frac{1}{4}$ lb	Ditto
Mother of thyme	45 lb	4 drachms	Hoffmann
Myrrh	1 lb	2 drachms	Neumann
	1 lb	3 drachms	Hoffmann
Nutmegs	1 lb	1 ounce	Geoffroy
	1 lb	1 ounce	Neumann
	1 lb	$\frac{1}{2}$ ounce	Sala
	1 lb	$\frac{3}{4}$ ounce	Cartheufer
Parley feeds	2 lb	1 drachm	Lewis
leaves, fresh	238 lb	2 ounces	Ditto
leaves, with the feeds	15 baskets	14 $\frac{1}{2}$ ounces	Dehne
Parfney feeds	8 lb	2 drachms	Lewis
Pennyroyal, in flower, fresh	13 lb	6 drachms	Ditto
Pepper, black	2 lb	ditto	Ditto

Name of the Vegetable.	Quantity.	Weight of the Oil.	Maker of the Experiment.
Pepper, black	1 lb	2½ drachms	Gaubius
—	1 lb	3 drachms	
—	1 lb	2½ drachms	
—	1 lb	4 scruples	
— Jamaica	1 ounce	30 grains	Neumann
Peppermint, fresh	4 lb	3 drachms	Lewis
Rhodium wood	1 lb	3 drachms	Neumann
—	1 lb	2 drachms	Sala
—	1 lb	3 ditto	
—	1 lb	3 ditto	
—	1 lb	4 ditto	
Roses	1 cwt	4 ditto	Tachenius
—	1 ditto	1 ounce	Homburg
—	12 lb	30 grains	Hoffmann
Rosemary, in flower	1 cwt	8 ounces	Lewis
— leaves	1 lb	2 drachms	Sala
—	1 lb	3 ditto	
—	3 lb	3½ ditto	
—	1 lb	1 drachm	
— fresh	70 lb	5 ounces	Cartheufer
Rue leaves	10 lb	2 drachms	Hoffmann
—	10 lb	4 ditto	
— in flower	4 lb	1 drachm	
—	60 lb	2½ ounces	
— with the seeds	72 lb	3 ounces	Lewis
Saffron, oriental	1 lb	5 scruples	
Sage leaves	34 lb	1½ ounce	
— in flower, fresh	27 lb	6 drachms	
— of virtue, in flower	1 lb	1½ drachm	Vogel
Sassafras wood	6 lb	1½ ounces	Hoffmann
—	6 lb	2 ounces	Neumann
—	30 lb	7 oz 1 drach.	Dehne
—	24 lb	9 ounces	
Savin bark	2 lb	5 ounces	Hoffmann
—	29 lb	9 ounces	Dehne
— wood	32 lb	½ ounce	
Saunders yellow	1 lb	2 drachms	
Scurvy grass, in flower, fresh	6 baskets	6 drachms	
Smallage seeds	1 lb	10 grains	Neumann
Stachas, in flower, fresh	5¼ lb	2 drachms	Lewis
Thyme, in flower, fresh	2 cwt	5½ ounces	Lewis
— dry	3½ lb	1½ drachm	
— (lemon) in flower, fresh	51 lb	1½ ounces	
—	98 lb	2½ ounces	
— a little dried	104 lb	3 ounces	Lewis
Wormwood leaves, dry	4 lb	1 ounce	
—	18 lb	1½ ounce	
Zedoary root	1 lb	1 drachm	Neumann
—	7 lb	1 ounce	Dehne

When

When the quantity of oil inherent in any particular substance is to be ascertained, it cannot be done directly on the first distillation, unless water were to be employed for this purpose, that is already impregnated with oil; because the water that is distilled from an oleaginous body, for the first time, always imbibes a considerable portion of its ethereal oil, and thus renders the calculation erroneous.

Neither are vegetables impregnated with the same quantity of oil at all seasons of the year; but herbs should only be applied to this purpose, when they are in full blossom, and many of them when they are run to seed. The roots are most impregnated with oil just before they send forth their radicles in the spring, but woods at the beginning of the winter. The maceration of green vegetables is needless, and indeed rather detrimental than otherwise; whereas, on the contrary, with dry and solid bodies it may be more useful, in which case some common salt is added, in order to prevent fermentation taking place. When fresh vegetables possess no particular volatile smell, it is rather of use to let them wither a little. Oils that yield a volatile odour must be distilled over with a gentle heat; but, on the other hand, such as at the same time are distinguished by a greater specific gravity, require a somewhat stronger fire for their distillation.

Most ethereal oils, it is true, swim upon the water with which they have come over in distillation; there are some, however, that sink in it. The method of separating the former is, first to leave the glass filled with the oily water at rest for some days, and then, by shaking it gently, to bring the oil up to the surface of the water. It may then be taken off either with a tea spoon, or with a small glass syringe. The best method, however, is to convey it by means of a short and slender skane of cotton, from the glass in which it is first received, into another glass tied to the upper part of this, by which means, at the same time, all the impurities which are frequently to be found in these oils, adhere to the cotton, and the oil is obtained pure and clear. With respect to the other species of these oils, which sink to the bottom in water, and are consequently heavier than water, this latter fluid must be made heavier by another body; for which purpose, nothing more is necessary to be done than to impregnate the water strongly with common salt, till the oil which lies at the bottom of the vessel rises to the surface, from whence it may then be separated in the manner above mentioned.

When essential oils, brought nearer to the resinous state by time, but not yet entirely deprived of their peculiar smell, are distilled with the heat of boiling water, a part of them rises in distillation, which has all the properties of essential oil freshly distilled. As this portion of oil is renewed by this operation, it is frequently practised on essential oils, which begin to be altered by age; and this second distillation is called the rectification of essential oils. We find in the cucurbit, after rectification, the resinous portion of the oil, which is no longer capable of being raised by the heat of boiling water. This oily residuum may, however, be attenuated by distilling with a stronger heat, and even all the volatility and thinness of essential oils may be given to it, as in the oil of Dippel, as well as other oily matters, by distillations sufficiently repeated. But such oils have never the peculiar aromatic smell of the original essential oil.

Essential oils are employed in painting, in spirituous liquors, used at the table, and at the toilette, in perfumes, and in medicine. As they act very powerfully, small doses only are given internally, as from one drop to four or five, incorporated with sugar, so as to form an oleo-saccharum, or with other drugs in form of pills.

OILS (FETID EMPYREUMATIC).

Under this name are comprehended all the oils of vegetable and animal matters

obtained by distillation with a heat superior to that of boiling water; because these oils have a disagreeable, burnt, or empyreumatic smell.

From this definition it is seen, that empyreumatic oils are not a distinct class: that they may be very different from each other, and may have nothing in common, but that they are all half-burnt; for when any vegetable or animal matter is exposed to a degree of heat superior to that of boiling water, all the oils which they contain, of whatever kind they may be, pass in distillation; but are altered, by the fire, in their colour, smell, and in many other of their peculiar properties. Besides, if the matter thus distilled contains several kinds of oils, they are all mixed together when they are rendered empyreumatic. If, for example, a vegetable matter be distilled which contains an oil that is sweet and not volatile, and also an oil in a resinous state, the fetid empyreumatic oil obtained will be only a mixture of these two oils half-burnt. The same may be said of animal matter, with regard to the oil properly called animal oil, and to the adipous oil which they contain.

No general properties, then, can be established as belonging to empyreumatic oils: they all vary according to the nature and proportion of the oils of which they are composed. Hence, in order to know the properties of any empyreumatic oil, it is necessary previously to know the kinds and proportion of oils contained in the substance from which it has been obtained, and also the changes suffered by each of these oils from the degree of heat requisite to render them empyreumatic. It will be only necessary here to observe, that all empyreumatic oils are acrid, and more or less soluble in spirit of wine; that the portion of these oils which rises first in distillation is always the thinnest; that by repeated distillations they may be rendered more and more thin and volatile; and that by a sufficient repetition of these rectifications, they may almost be entirely deprived of their empyreumatic smell, so that only a pungent and penetrating smell shall remain; which seems to be common to all oils treated in this manner.

OILS, improperly so called. Many preparations were by the ancient chemists called oils, merely from their consistence, although in other respects they were entirely different from oil. These improper names ought to be abolished, and they are accordingly falling into disuse by modern chemists. Nevertheless, as they are found in most chemical books in the time of Lemerier, and as many of them are still frequently employed, we shall explain in a few words the chief of them.

OIL OF ANTIMONY. By this name the butter of antimony, and some other solutions of antimony by acids, are called. See *ANTIMONY*.

OIL OF ARSENIC. This is a combination of aerated marine acid with arsenic, and is made precisely in the same manner as butter of antimony. Equal parts of arsenic and of corrosive sublimate are mixed and distilled together, by which a liquor comes over similar to the butter of antimony. This is a very powerful, but, at the same time, very dangerous caustic. This shews, that arsenic, like regulus of antimony, and several other metallic substances, is capable of decomposing corrosive sublimate, by seizing its acid. Accordingly, mercury is revived in this as in all the similar operations. These combinations resemble the liquor of Libavius, which Adet has well explained. See *TIN*.

OIL OF MERCURY. When water is added to a solution of mercury in vitriolic acid to form the precipitate called turbith mineral, the acid thus diluted still retains a portion of mercury dissolved, which is properly a vitriol of mercury. This salt, which is crystallizable, may be obtained by evaporating the water which keeps it dissolved. When exposed to a moist air, it deliquesces into a liquor which Lemerier calls oil of mercury.

Lemerier

Lemeri also gives the name of oil of mercury to a solution of corrosive sublimate in spirit of wine.

OIL OF LEAD. This is a solution of salt of lead in the essential oil of turpentine. This salt is to be put into a matrafs, and upon it oil of turpentine is to be poured, till it covers the salt with a thickness of some fingers, and the whole is to be digested during ten or twelve hours. The liquor, says Lemeri, acquires a red colour. The author directs that the solution should be concentrated, by distilling from it a part of the oil of turpentine; and he recommends it for its utility in cleansing and cicatrizing ulcers, particularly those which are putrid. This preparation, which Macquer says is certainly a powerful antiseptic, must be very proper for these purposes.

Amongst the oils improperly so called, this is one of those to which the name of oil has been with least impropriety given; for the basis of it is actually oil, and that oil really keeps the lead in solution. Lemeri affirms, that we may thus entirely dissolve a given quantity of oil of turpentine. This preparation, which has only been made for medicinal purposes, is interesting also in chemistry, and deserves a particular examination.

OIL OF SULPHUR. Some chemists have given this name to the concentrated acid of sulphur. See **SULPHUR**.

OIL OF TARTAR BY DELIQUIM. A name very frequently given to fixed alkaline salt resolved into a liquor by the moisture of the air, or even to a solution of that salt in water. This name is unsuitable, not only as the liquor is not of the nature of oil; but also because a true oil of tartar is obtained by distillation of tartar. This liquor ought to be called alkali of tartar, or liquid vegetable alkali. See **ALKALI FIXED VEGETABLE**, and **TARTAR**.

OIL OF VENUS. Lemeri gives this name to the salt formed by the union of copper with the nitrous acid, when it is resolved into a liquor by the moisture of the air. It is a caustic and escharotic, like all other similar combinations of metallic matters with any acids to which the name of oil was formerly given.

OIL OF VITRIOL. This name is very commonly, but improperly, given to concentrated vitriolic acid. See **ACID VITRIOLIC**.

OINTMENT. A compound of oily or unctuous matter, with powders or other substances, made of the consistence of butter, for medical use.

OLEO-SACCHARUM. This name is given to a mixture of oil and sugar, incorporated with each other, to render the oil more easily diffusible in watery liquors. Sugar and all saccharine matters have in general a quality somewhat saponaceous, and consequently are capable of producing this effect in some measure. These oleo-saccharums are used in pharmacy, as a method of administering essential and other oils.

OLIBANUM. Thus, frankincense. A gum resin, the product of the *Juniperus Lycia* Linn. brought from Turkey and the East Indies, usually in drops or tears. The ancients distinguished various sorts of olibanum, as, 1. Olibanum, or thus masculum, melax, melafon, testiculatum, or the purest, yellowish-white, round tears, which were frequently joined two together. 2. Thus fœmineum, or the yellower and more impure. 3. Thus mammosum, or larger oblong roundish masses, somewhat resembling a woman's breasts. 4. Thus granulofum, or small granules. 5. Thus corticosum, or such masses as have pieces of the bark of the tree adhering. 6. Thus orobæum, or mica thuris; small fragments, or particles broke off in carriage, &c. 7. Manna thuris, the finer dust. 8. Thus indicum, or large masses, composed of different coloured tears, white and blackish, joined together.

At present only two kinds are distinguished: the finer and purer tears are called olibanum in grains; the more impure fragments and masses, common olibanum, or olibanum in forts. The best is of a yellowish white colour, solid, hard, and brittle: when chewed for a little time, it renders the spittle white, and impresses an unpleasant bitterish taste; laid on burning coals, it yields an agreeable smell.

Out of an ounce of the pure tears, rectified spirit of wine dissolved five drams two scruples and six grains: from the remainder, water took up two drams and five grains. Another ounce gave out to water at first three drams and a scruple; and afterwards to spirit, four drams thirty-three grains. The indissoluble matter, in the first operation, weighed twelve grains; in the other fourteen. Both the distilled spirit and water tasted pretty strongly of the olibanum, but no separable oil could be obtained. Olibanum is accounted corroborant, and supposed to be particularly serviceable in disorders of the head, stomach, and breast. Its principal use is in plasters, unguents, and in fumigations.

Olibanum is not, in any of its states, what is called thus or frankincense in the shops. The common frankincense is a solid, brittle resin, brought to us in little globes or masses, of a brownish or yellowish colour on the outside, internally whitish or variegated with whitish specks; of a bitterish, acrid, not agreeable taste, without any considerable smell. It is supposed to be the produce of the pine tree, which yields the terebinthina communis; and to concreate on the surface of the terebinthinate juice soon after it has issued from the plant.

OLIVES. The oil of this fruit is well known; it is obtained by expression. The process used in the South of France, as described by Chaptal, is very simple. The olive is crushed by a mill stone, placed vertically, rolling upon an horizontal plane. The paste thus formed is strongly pressed in a press; and the first oil which comes out is called virgin oil. The marc or pulp is then moistened with boiling water; the mass is again pressed; and the oil which floats upon the water carries with it part of the parenchyma of the fruit and a great part of the mucilage, from which it is difficultly cleared.

The difference in the kind of olive produces a difference in the oil; but the concurrent circumstances likewise establish other differences. If the olive be not sufficiently ripe, the oil is bitter; if it be too ripe, the oil is thick and glutinous. The method of extracting the oil has a very great influence on its quality. If the oil-mills are not kept sufficiently clean, the mill-stones, and all the utensils, are impregnated with a rancid oil, which cannot but communicate its flavour to the new oil. In some countries it is usual to lay the olives in heaps, and suffer them to ferment before the oil is drawn. By this management the oil is bad; and this process can only be used for oil intended for the lamp or for the soap-boiler.

OLLARIS LAPIS. See **LAPIS OLLARIS.**

ONIONS. Neumann examined this root; he could not obtain any oil by distillation from twelve pounds of onions sliced, and treated with water in the usual manner. The water which came over contained all the active parts of the onions.

This root contains much aqueous moisture. It lost near four-fifths of its weight by drying, and the onions when half dry smelt like rue.

An ounce of the dry root yielded to Neumann with rectified spirit six drams of extract, and afterwards with water one dram eighteen grains. Another ounce, treated first with water, gave six drams thirty-five grains, and afterwards with spirit half a dram; the indissoluble residuum weighed in the first case two scruples sixteen grains, in the latter eight grains more. The distilled spirit is somewhat

somewhat impregnated with the oil of the onion, discoverable rather by its taste than by its smell; the more subtile odorous parts having been dissipated in the previous exsiccation. The spirituous extract tastes strongly of the onion: this is the strongest preparation in point of taste, and the distilled water in smell.— This root, besides its culinary uses, has been employed medicinally, as a resolvent and diuretic, in cachexies, dropsies, nephritic cases, &c.

ONYX. An agate generally opaque, or but slightly transparent, consisting of differently coloured veins, parallel to each other, sometimes in straight and sometimes in curved lines.

OPAL. *Opalus*, *pædros* Græcorum, the *girasole* of the Italians.

It is the most beautiful of all the flint kind, owing to the changeable appearance of its colours by reflection and refraction, and must therefore be described under both these circumstances.

Cronstedt distinguishes two kinds of opal: the opal of Nonnius, or the fangenen of the Indians. It loses its colour and transparency in fire; and in other respects is affected by it as a quartz or flint. It fuses with borax, though difficultly; and its specific gravity is 1.900 and upwards.

This opal appears olive-coloured by reflection, and seems then to be opaque; but when held against the light, is found transparent, and of a fine ruby red colour.

That opal is supposed to have been of this kind, which Pliny mentions in his *Natural History*, book xxxvii. chap. 6, and which, he says, was in the Senator Nonnius's possession, who rather chose to suffer banishment than part with it to Anthony.

This stone was in Rome at that time valued at 20,000 sesterces. The stone here particularly described was found in the ruins of Alexandria: it is about the size of a hazle-nut, and was bought for a trifle of a French drogoman* named Roboly, and presented to the French General Consul Lironcourt, who afterwards offered it to sale in several places for the sum of 40,000 rix dollars. See *Hasselquist's Travels to the East*, under the article opal.

There is, however, another of the same kind in Sweden, which by reflection appears rather brown; but by refraction it is red with violet veins. 2. The white opal; its ground is white of a glass-like complexion, from whence are thrown out green, yellow, purple, and bluish rays; but it is of a reddish or rather flame-colour, when held against the light.

Of this white opal there are three species. 1. Of many colours, or the oriental opal. 2. Of a milky colour, from Eibentock in Saxony. 3. Bluish and semi-transparent: this is not so much valued as those which are more opaque, because it is easier to be imitated by art.

Not only this, but also some of the other kinds of opals have been well imitated by art, there being found compositions of glass, which they very different colours by refraction from what appears by reflection. A curious ancient one of this kind is to be seen in the royal abbey of St. Denis, near Paris, which is green on the outside, and shews a fine ruby colour when viewed against the light. Magellan makes mention of glass-pastes, some made in London, by Edward Delaval, Esq. F. R. S. and some others by Mr. More, Secretary to the Society of Arts, which appeared of a yellow brown, or other colour by reflection; but when held against the light, transmitted a fine blue, or a purple and red colour, like

* That is to say, interpreter and broker, in Turkey.

sapphires, rubies, garnets, hyacinths, &c. Wallerius points out the proper ingredients to make these pastes.

The principal effect of the opal, namely, that of reflecting one colour and transmitting another, is observable in a variety of coloured, or imperfectly transparent pastes. It is common to all solids or fluids, on account of their imperfect transparency, but is not perceived in the greater number of them, because a large mass is in general required to intercept any considerable portion of the rays of light. Thus the sea-water is blue by reflected light, and red by transmitted, as Dr. Halley observed in the diving bell. So likewise the common colour of the air by reflection is blue, and this blue colour tinges the images of distant mountains, in the clear elevated regions of Switzerland and elsewhere; but it is red by transmitted light, as is seen by the colour of the setting sun, or moon, and that of the rays which fall on the clouds in the morning or evening, which differ according to the length of the portion of air through which the light passes. There is, however, another property of the opal, which has not been imitated by art, and affords the chatoyant effect, or variation of colour according to the position. This seems to arise from the foliated texture of the natural stone, which may be supposed to produce numerous extremely minute fissures, in certain determinate directions. The true opal may therefore be distinguished by this property whenever it appears; or more generally by its hardness, for none of the artificial stones resist the file.

The oculus mundi, or hydrophanes, is a curious species of the opal. See HYDROPHANES.

OPIUM. On wounding the heads or stalks of the poppy, a milky juice exudes, which exsiccated proves a fine kind of opium. In Natolia, Cilicia, Cappadocia, in the neighbourhood of Cairo, and in several other parts of the Turkish dominions, poppies are cultivated for this use in fields, as corn among us. The method of collecting the juice by incision is described by Kämpfer, in his *Amœnitates Exoticæ*. This process, however, is now but rarely practised, the consumption of this drug being too great to be supplied by that method of collection. The best sort of the officinal opium is the expressed juice of the heads, or of the heads and the upper part of the stalks, inspissated by a gentle heat: this was formerly called meconium, in distinction from the true opium or juice which issues spontaneously. The inferior sorts (for we find considerable differences in the quality of this drug) are said to be prepared by boiling the plant in water, and evaporating the strained decoction; but as no kind of our opium will totally dissolve in water, the juice is most probably extracted by expression. Neumann was informed by some Turks at Genoa and Leghorn, that in some places the heads, stalks, and leaves are committed to the press together, and that this juice inspissated affords a very good opium.

On this head Dr. Lewis remarks, that the point has not, as yet, been fully determined. It is commonly supposed, that, whatever preparations the Turks may make from the poppy for their own use, the opium brought to us is really the milky juice collected from incisions made in the heads, as described by Kämpfer. It is certain, that an extract made by boiling the heads, or the heads and stalks in water, is much weaker than opium; but it appears also that the pure milky tears are considerably stronger.

The principles separable from opium are, a resin, gum, a minute portion of saline matter, water, and earth. The resin is of two kinds; one more truly resinous, of a solid consistence, in its nature more fixed, and in its operation
more

more sluggish; the other softer and thinner, more volatile, and of much more speedy and powerful activity. The saline matter is of the acidulous kind, analogous to the essential salts of other vegetables: its proportion is so small, that it is not easily separable in its proper form, though it has sometimes happened, that actual crystals have concreted in a watery solution of opium. The resin, the gum, and the salt, are very intimately combined together, inasmuch that all the three dissolve almost equally in water and in spirit: it is probably to the saline principle, in this and other vegetables, that this intimacy of union is in great measure to be ascribed.

Four ounces of opium, treated with highly rectified spirit of wine, yielded three ounces and four scruples of resinous extract, five drams and a scruple of indissoluble impurities remaining. On taking four ounces more, and applying water at first, Neumann obtained two ounces five drams and one scruple of gummy extract; and, by digesting the residuum in spirit of wine, three drams and one scruple of resinous extract; the indissoluble part amounting here to seven drams and a scruple. In distillation, rectified spirit brought over little or nothing; but the distilled water was considerably impregnated with the particular ill smell of the opium.

The subtle soft kind of resinous matter discovers itself in great measure in the bare watery solution of opium, generally rising to the surface in form of a fat, unctuous, frothy substance. This is the strongest and most active part of the opium; a few grains are sufficient to kill a dog, who could bear a whole dram of crude opium. From a pound of opium we may collect two or three drams of this balsam-like substance; but we are not to imagine that this is the whole quantity which the opium contains: besides what thus spontaneously separates, a part remains combined with the rest of the juice, and probably is the principle, or the direct seat of the principle, that gives activity to the whole.

As opium in substance is frequently found to be productive of unfavourable consequences, different methods have been contrived for correcting or rendering it more universally safe. In this enquiry, every one has proceeded agreeably to the idea he had formed of the composition of opium, and endeavoured to counteract that principle in which he imagined its activity to consist: hence the great variety of pretended correctors. Those who ascribed its power to a volatile alkaline salt, thought to mitigate it by acids, as spirit of vitriol, dulcified spirit of vitriol, citron juice; whilst others, deducing its operation from an acid, used alkalies for the correctors. Some, presuming it be of a cold nature, joined to it hot substances, as cinnamon, pepper, ginger, euphorbium, &c. These kinds of additions accompany it in the ancient electuaries; and as most electuaries formerly received opium in their composition, opiatum became a general name for the form itself. Some, imagining opium to be impregnated with a narcotic sulphur, endeavoured to divest it of that offending principle, by cutting it into thin slices, and gently roasting it till it began to smell agreeably; others, afraid that this degree of torrefaction was insufficient for the total dissipation of the sulphur, had recourse to a stronger heat, and destroyed the opium and all its powers by burning. On what principles henbane seeds and other stupefactive bodies were joined to opium, it is hard to guess.

Neumann is persuaded that the narcotic matter of opium is diffused throughout its whole substance; but that it resides most copiously, and in the most eminent degree, in its finer, subtle, volatile parts; that these parts are capable of being

highly concentrated and exalted in their power by art. He asserts his knowledge of a certain preparation of opium, by which a whole chamber full of men may be presently stupefied, and deprived of their senses, and even of their lives also, without a single grain being swallowed; that the narcotic matter cannot be separated in any visible form, without some admixture of the other parts; that opium cannot be totally freed from it, but by a destruction of the opium itself; that it operates nearly in the same manner as the vapour of burning charcoal, or the subtle exhalations from fermenting liquors.

To dissipate a part of this subtle principle, and thus render the opium more mild and innocent, he recommends fermentation. But Dr. Lewis justifies the present practice by remarking, that it is a point of primary consequence, in preparing a medicine of such activity as opium, that it be always made of equal and certain strength: fermentation, if it really weakens the power of the opium (as it probably does), must for that very reason render its strength vague, and impossible to be ascertained. It does not appear that the corrections of opium by fermentation; or other like processes, do any thing more than what may be equally effected by a diminution of the dose.

This judicious observation may also be applied to the very laborious processes of Baumé and others, who do not seem to have succeeded in producing any substance more uniform in its operation than the crude opium.

OPOBALSAM. The most precious of the balsams is that commonly called Opobalsam, or Balm of Gilead, Opobalsamum, Balsamelæon, Balsamum verum album, Ægyptiacum, Judaicum, Syriacum, Gileadense, è Mecca, &c. This is the produce of certain trees, which grew formerly in the valley of Jericho, but after the conquest of the Holy Land by the Turks were removed to Grand Cairo, where the balsam plantation is said to be now guarded by Janissaries, and the resinous juice collected for the Sultan only.

The true balsam is of a pale yellowish colour, clear and transparent, about the consistence of Venice turpentine, of a strong, penetrating, agreeable, aromatic smell, and a slightly bitterish pungent taste: by age it becomes yellower, browner, and thicker, losing by degrees, like essential oils, some of its finer and more subtle parts. To spread, when dropt into water, all over the surface, and to form a fine, thin, rainbow-coloured cuticle, so tenacious that it may be taken up entire by the point of a needle, were formerly infallible criteria of the genuine opobalsam. Neumann however had observed, that other balsams, when of a certain degree of consistence, exhibit these phænomena equally with the Egyptian.

This balsam, according to Prosper Alpinus, is obtained from a small evergreen tree or shrub, about the size of the privet or cytissus, with flexible branches, and a few leaves which resemble those of rue, or rather of the lentisk-tree, set in pairs along a middle rib, with an odd one at the end. The branches are covered with two membranous thin barks, the outermost of a reddish-brown colour, the inner greenish; the woody part is white. The flowers are of a purplish-white colour, in shape like those of acacia: the fruit is a small reddish-black berry, containing yellow seeds.

The wood is said to be inodorous, the bark fragrant and aromatic, the flowers highly odoriferous; the berries to be odorous, acrid and bitter, and to yield a yellow liquor of the appearance of honey. The branches and dry berries have been sometimes brought into Europe, and kept in the shops for medicinal use,

the former under the name of *xylobalsamum*, the latter of *carbobalsamum*: whatever smell or taste these substances may have when fresh, they have little of either as they come to us.

The precious balsam exudes in very small quantities, from slight incisions made in the bark. According to the author above mentioned, it is at first white, of a very strong penetrating smell of the turpentine kind, but sweeter and more fragrant; and of a bitter, acrid, astringent taste. It looks in part turbid and thick, like the oil newly expressed from olives: afterwards it grows extremely thin, limpid and light; its colour changes to a greenish, then to a gold yellow, and by long keeping to that of honey: it now grows thick like turpentine, and loses much of its fragrance.

Inferior sorts of balsam are said to be obtained by boiling the branches in water: when the liquor begins to boil, a thin oil arises to the surface, and on continuing the coction, a grosser and a thicker one.

Mr. Geoffroy observes, that a solution of balsam of Gilead made in spirit of wine, turns milky on being poured into water, but does not deposit any precipitate; and that this mixture is used in France as a cosmetic. He says, an equal quantity of oil of almonds is previously mixed with the balsam; but this ingredient can be of no use, as it totally separates and falls to the bottom, whilst the balsam dissolves in the spirit.

OPODELDOC. A solution of soap in ardent spirit, with the addition of camphor and essential oils. It is used externally against rheumatic pains, sprains, bruises, and other like complaints.

OPOPANAX. A concrete gummy resinous juice, obtained from the roots of an umbelliferous plant (*Panax pastinacæ folio* C. B. *Pastinaca opopanax* Lin.) which grows spontaneously in the warmer countries, and bears the colds of this. The juice is brought from Turkey and the East Indies, sometimes in round drops or tears, but more commonly in irregular lumps of a reddish-yellow colour on the outside, with specks of white, inwardly of a paler colour, and frequently variegated with large white pieces. It has a peculiar strong smell, and a bitter, acrid, somewhat nauseous taste. Its virtues are those of an attenuating and aperient medicine.

An ounce of opopanax, treated with rectified spirit of wine, gave two drams two scruples and six grains of resinous extract, and afterwards with water, three drams of gum; two drams and a scruple remaining undissolved. Another ounce treated first with water, yielded three drams two scruples and six grains of gummy extract; and afterwards, with rectified spirit, one dram of resin, the indissoluble part amounting to three drams and a scruple. Both the distilled water and spirit are impregnated with the flavour of the opopanax; but no actual oil can be separated, at least on distilling small quantities of the juice.

ORANGE. The flowers of orange trees afford, by distillation, a very fragrant essential oil. From the rind of the fruit an essential oil may be obtained by expression. The juice of the fruit contains an essential acid salt, mixed with much mucilage. This salt may be obtained in crystals, by diluting the juice, clarifying it with whites of eggs, and evaporation. The juice, not depurated from its mucilage, is apt to become mouldy; but by the above-mentioned method of depuration, a saline extract may be made, capable of being preserved, and possessed of the same medicinal qualities as the juice, which is said to be very powerful in the scurvy; or it may be advantageous to treat it in the same manner as lemon juice. See **LEMONS**.

The essential oil may be procured by pressure of the peeling against an inclined glass. In Provence and in Italy the peeling is rasped; by which means the vesicles are torn, and the oil flows into the vessel destined to receive it: this oil suffers the parenchyma which goes along with it to subside, and becomes clear by standing.

If a lump of sugar be rubbed against these vesicles, it imbibes the volatile oil, and forms an oleo-saccharum, soluble in water, and very proper to give an aromatic flavour to certain liquids.

ORES are native substances, containing the metals in an altered state, in all cases either combined with some foreign substance, which deprives them of malleability and metallic brilliancy, or else so intimately mixed, that the particles of metal cannot be discerned. In all cases wherein the metallic substance is clearly distinguishable, it is not called an ore, but a native metal.

The metal in most ores is in the state of calx, viz. combined with vital air, according to the modern theory; and moreover deprived of phlogiston, according to the ancient theory. When ores contain nothing but the calx of the metal with the addition of more or less fixed air, they are said to be calciform; but when they are combined with other substances, they are said to be mineralized. The mineralizers are either arsenic or sulphur. Besides the mineralizers there are various stony matters, which accompany ores in a certain peculiar way with regard to crystallization and appearance; which has occasioned miners to consider them as possessing an affinity to the ore. This stony accompaniment, of which a better notion may be formed by inspection of ores than from any general description, is called the matrix of the ore. The rocks that lie over the veins are called the roof; those that lie under them the floor, and by some the hading. The matrix is almost always a finer species of stone than the surrounding rocks, though of the same genus. Even the rocks themselves are of a finer grain as they approach the vein. There is no matrix peculiarly appropriated to any metal; it has only been remarked, that tin is generally found among stones of the siliceous genus, and lead very frequently among those of the calcareous. See METALLURGY, and the several metals.

Ores therefore consist *, 1. of metallic substances in a calcined or rather calciform state; or, 2. of these substances combined with other matters, with which they are said to be mineralized.

Calcined metallic substances, or calciform ores, are metallic substances deprived of phlogiston, and in the state of a calx, or metallic earth. See CALX. Such are all ferruginous ochres, which are calces of iron.

Mineralized ores are,—1. Simple, containing only one metallic substance; or, 2. Compound, containing two or more metallic substances.

Of the simple, and also of the compound ores, four kinds may be distinguished:

1. Ores consisting of metallic substances, mineralized by sulphur. Such is the lead-ore, called galena, composed of lead and sulphur.

2. Ores consisting of metallic substances mineralized by arsenic. Such is the white pyrites, containing iron and arsenic.

3. Ores consisting of metallic substances, mineralized by sulphur and by arsenic. Such is the red silver-ore, containing silver, arsenic, and sulphur.

4. Ores consisting of metallic substances, mineralized by saline matters. Such are the native vitriols. Such also is probably the corneous silver ore, which,

* The remainder of this article is taken chiefly from Keir's Notes to Macquer's Dictionary.
according

according to Cronstedt, is a luna cornea, or silver combined with marine acid. To this class also may be referred the silver mineralized by an alkaline substance, which Mr. Von Justi says he has discovered.

Henckel, and after him Cramer and Macquer, affirm, that in mineralized ores, besides the above-mentioned metallic and mineralizing substances, are also contained a metallic and an unmetallic earth. But Wallerius affirms, that the existence of such earths cannot be shewn, and that sulphur is incapable of dissolving unmetallic earths, and even the calces of all metallic substances, excepting those of lead, bismuth, and nickel.

Metals and metalliferous ores are found in various places.

I. They are found under water, in beds of rivers, lakes, and seas, and chiefly at the flexures of these: such are the auriferous and ferruginous sands, grains of native gold, ochres, and fragments of ores washed from mines.

II. They are found dissolved in water: such are the vitriolic waters containing iron, copper, or zinc.

III. They are found upon the surface of the earth. Such are many ochres; metalliferous stones, sands, and clays; and lumps of ores. Mr. Gmelin says, that in the northern parts of Asia ores are almost always found upon or near the surface of the ground.

IV. They are found under the surface of the earth. When the quantity of these collected in one place is considerable, it is called a mine.

Subterranean metals and ores are differently disposed in different places.

1. Some are infixed in stones and earths, forming nodules or spots diversely coloured.

2. Some are equally and uniformly diffused through the substance of earths and stones, to which they give colour, density, and other properties. Such are the greatest part of those earths, stones, sands, clays, crystals, flints, gems, and fluors, which are coloured.

3. Some form strata in mountains. Such are the slates containing pyrites, copper-ore, lead-ore, silver-ore, or blend. These lie in the same direction as the strata of stones, betwixt which they are placed; but they differ from the ordinary strata in this circumstance, that the thickness of different parts of the same metalliferous stratum is often very various; whereas the thickness of the stony strata is known to be generally very uniform.

4. Fragments of ores are frequently found accumulated in certain subterranean cavities, in fissures of mountains, or interposed betwixt the strata of the earth. These are loose, unconnected, frequently involved in clay, and not adherent to the contiguous rocks or strata immediately, nor by intervention of spar or of quartz, as the ores found in veins are. Tin and iron mines are frequently of the kind here described.

5. Large entire masses of ores are sometimes found in the stony strata of mountains. These are improperly called cumulated veins, because their length relatively to their breadth and depth is not considerable.

6. Some instances are mentioned of entire mountains consisting of ore. Such is the mountain Taberg in Smoland; and such are the mountains of Kerunavara and Luofavara in Lapland, the former of which is 1400 perches long, and 100 perches broad. These mountains consist of iron ore.

7. Lastly, and chiefly, metals and ores are found in oblong tracts, forming masses called veins, which lie in the stony strata composing mountains.

The direction of veins greatly varies; some being straight, and others curved.

Their

Their position also respecting the horizon is very various; some being perpendicular, some horizontal, and the rest being of the intermediate degrees of declivity.

The dimensions, the quality, and the quantity of contents, and many other circumstances of veins, are also very various. Miners distinguish the several kinds of veins by names expressive of their differences. Thus veins are said to be deep; perpendicular; horizontal, or hanging, or dilated; rich; poor; morning, noon, evening, and night veins, by which their direction towards that point of the compass where the sun is at any of these divisions of the natural day, is signified.

Some parts of veins are considerably thicker than others. Small veins frequently branch out from large veins, and sometimes these branches return into the trunk from which they issued. These veins, from which many smaller veins depart, have been observed to be generally rich.

Veins are variously terminated: 1. by a gradual diminution, as if they had been compressed, while yet soft, by superincumbent weight, or by splitting and dividing into several smaller veins: or, 2. they are terminated abruptly, together with their proper strata in which they lie. This abrupt termination of veins and strata is occasioned by their being crossed by new strata running transversely to the direction of the former; or by perpendicular fissures through the strata; which fissures are frequently filled with alluvial matters, or with water, or are empty. These perpendicular fissures seem to have been occasioned by some rupture or derangement of the stratum through which the vein passes, by which one part of it has been raised or depressed, or removed aside from the other, probably by earthquakes. Where the vein is terminated abruptly it does not cease, but is only broken and disjointed; and is often recovered by searching in the analogous parts of the opposite side of the deranged stratum. A principal part of the art of miners consists in discovering the modes of their derangements from external marks, that they may know where to search for the disjointed vein.

The contents of veins are metals and metalliferous minerals, as the several kinds of ores, pyrites, blends, guhrs, vitriols; the several kinds of fluors, spars, quartz, horn-blend, in which the ores are generally imbedded, or enveloped, and which compose the matrix of the ore; stalactites; crystallizations of these metalliferous and stony substances, encrusting the small cavities of the circumjacent rock; and lastly, water, which flows or drops through crevices in that rock.

In a vein, ores are found sometimes attached to the rock or stratum through which the vein runs, but more frequently to a matrix which adheres to the rock; and sometimes both these kinds of adhesion occur in the same vein at different places. Frequently between the matrix and the rock a thin crust of stone, or of earth, is interposed, called by authors the *finbria* of the ore.

The matrix, or the stone in which the ore lies enveloped, is of various kinds in different veins. And some kinds of stone seem better adapted than others to give reception to any ore, or to the ores of particular metals. Thus quartz, spar, fluors, and horn-blend, give reception to all ores and metals; but slates chiefly to copper and silver, and never to tin; calcareous and sparry matrices, to lead, silver, and tin; and mica to iron.

Veins lie in strata of different kinds of stone; but more frequently in some kinds of stone than in others. Thus, of the simple or uncompounded stones which compose strata, the following are metalliferous: calcareous stones; slaty sand
stone

stone (*cos fissilis arenosus Wallerii*); felspar (*spatum pyramacum sive scintillans*); quartz, sometimes Jasper, frequently flates, and chiefly micaceous or talky stones, and horn blend (*lapis corneus Wallerii*; *bolus indurata particulis squamosis Cronstedt.*) No veins have been found in gypseous or siliceous strata, though cherts and flints frequently contain metallic particles, and some instances have been observed of ores of silver and tin in alabaster. Of compound stones, those are said to be chiefly metalliferous which consist of particles of horn-blend. Veins have also been found in the red granite; but seldom, if ever, in any other granite, or in porphyry. In general, veins are more frequently found in soft, fissile, and friable strata, than in those which are compact and hard.

A vein sometimes passes from one stratum into the inferior contiguous stratum. Sometimes even the veins of one stratum do so correspond with those of an inferior stratum, the contiguity of which with the former is interrupted by a mass of different matter, through which the veins do not pass, that they seem originally to have been continued from one stratum to the other. Thus, in the mines of Derbyshire, where the veins lie in strata of limestone, the contiguity of which strata with each other is interrupted in some places by a blue marle or clay, and in other places by a compound stone called roadstone, the veins of one stratum frequently correspond with the veins of the inferior stratum of lime-stone; but are never continued through the interposed clay or roadstone. But we must observe, that these interposed masses, the blue marle, clay, and roadstone, have not the uniform thickness observable in regular strata, but are (especially the roadstone) in some places a few feet in depth, and in others some hundreds of yards. The above disposition seems to indicate, that these several strata of limestone have been originally contiguous; that the veins now disjointed have been once continued; that these strata of limestone have been afterwards separated by some violent cause, probably by the same earthquakes which have in a singular manner shattered the strata of this mountainous country; that the interstices thus formed between the separated strata have been filled with such matters as the waters could insinuate, probably with the mixed comminuted ruins of shattered strata; or with the lava of neighbouring volcanos, of which many vestiges remain.

To the above historical sketch of mines it may not be improper to add some conjectural remarks concerning their formation:

Those ores which are found under water (I); upon the surface of the earth (III); in fissures of mountains and subterranean cavities; accumulated, but not adherent to the contiguous rocks (IV); seem from their loose, unconnected, broken appearances to have been conveyed by alluvion.

All martial ochres have probably been separated from vitriolic ferruginous waters (II), either spontaneously or by calcareous earth; and these waters seem to have acquired their metallic contents by dissolving the vitriol which is produced by the spontaneous decomposition of martial pyrites. The ochres of copper, zinc, and perhaps of several other metals, have probably been precipitated from vitriolic waters by some substance, as calcareous earth, more disposed to combine with acids; and these vitriolic waters have probably been rendered metalliferous, by dissolving the vitriols produced by a combustion of cupreous pyrites, and of the ore of zinc called blend; for these minerals are not, as martial pyrites is, susceptible of decomposition spontaneously, that is, by air and moisture.

The metalliferous nodules and spots (IV. 1.), seem to have been infixed in stones while these were yet soft. Perhaps the metalliferous and lapideous particles

cles were at once dissolved and suspended in the same aqueous menstruum, and during their concretion crystallized distinctly, as different salts do when dissolved in the same fluid.

The earths and stones uniformly coloured by metals (IV. 2.) were also probably in a soft state while they received those tinges. The opaque-coloured stones seem to have received their colour from metallic calces, mixed and diffused through the soft lapideous substance; and the transparent-coloured stones have probably received their colours from vitriolic salts, or from metallic particles dissolved in the same water which softened or liquefied the stony substance; which metallic salts and particles were so much diffused, that they could not be distinctly crystallized. That all stones have been once liquid and dissolved in water, appears probable not only from their regular crystallized forms, but also from the solubility of some stone, as of gypseous and calcareous earths in water; and from the water which we know is contained in the hardest marbles, as well as in alabasters; to which water these stones owe the crystallization of their particles.

The veins called cumulated (IV. 5.), and the entire metalliferous mountains (IV. 6.), are believed by Wallerius to be analogous to the nodules (IV. 1.). These metalliferous substances seem to have been originally formed or concreted in the places where they are found.

The metalliferous strata (IV. 3.) have probably been insinuated between the lapideous strata, after the separation of these from each other by some violent cause; in the same manner in which it was supposed that the clay and toadstone have been insinuated betwixt the several strata of limestone in Derbyshire. The matters thus insinuated may have been either fluid, which would afterwards crystallize, and form entire regular masses; or they may have been the ruins of shattered strata, and veins brought by waters, and there deposited: in which case they will appear broken and irregular. The metalliferous strata, though frequently confounded with the horizontal or dilated veins, may be distinguished, according to Wallerius, from these by the following properties:—1. They are generally thinner and much broader than the veins called dilated. 2. They are seldom found at a greater depth than 100 perches, and generally in the neighbourhood of veins, from which they probably have received their contents. 3. From their want of the thin incrustations called *fimbriæ*, which, as has been observed, are frequently interposed betwixt the rock and the ore, or its matrix; and from their want of the other properties of veins.

But in veins properly so called the strongest marks exist of ores having been there concreted, and not carried thither and deposited in their present state. Their regular, unbroken appearance, their adhesion to the contiguous rock, either immediately or by intervention of a matrix, the regular appearance of this matrix enveloping the ore, the frequent crystallization of the ore, and of the other contents of the vein, indicate that ores, as well as the other solid contents, have been there concreted from a fluid to a solid state.

Most authors believe, that veins, and the perpendicular clefts in the stony strata of mountains, called fissures, have been produced by the same cause; or, rather, they consider veins only as fissures filled with metalliferous matters. They further believe, that fissures have been occasioned by the exsiccation of strata, while these were passing from a fluid to a solid state. Wallerius thinks, that fissures have been formed from exsiccation; but that veins were channels made through the strata, while yet soft and fluid, by water, or by the more fluid parts of the strata, penetrating and forcing a passage through the more solid parts.

parts. He thinks, that these fluid parts conveyed thither their metalliferous and stony contents, which were then coagulated or concreted. He supports his opinion by observing, that all the veins of the same stratum generally run parallel to each other; that they frequently bend in their course; that the same vein is sometimes contracted and sometimes dilated; that veins are frequently terminated by being split or divided into inferior veins; that veins are frequently wider at bottom than at top, whereas fissures are always widest at top, and are very narrow below: all which appearances, he thinks, could not have been produced by exsiccation. From these reasons, fissures appear to have had a different, and from the disjunction and rupture of veins crossed by fissures, they seem to have had a later, origin than veins. Whether fissures could have been produced by the very gradual exsiccation of these large masses, or strongly coherent matter; or whether they have been produced by the same violent causes, namely, earthquakes, by which the strata in which fissures are generally found have been broken and deranged, and by which metalliferous mountains themselves have been formed, or their strata raised above their original level, as some others have with great probability conjectured, cannot with certainty be determined.

Veins are seldom, if ever, found but in mountains; the reason of which may not improbably be, that in metalliferous mountains we have access to the more ancient strata of the earth, which in plains are covered with so many deposited, alluvial, and other later strata, that we can seldom if ever reach the former. That these mountains consist of strata which have been originally lower than the upper strata of adjacent plains, appears from an observation which has been made, that the strata of mountainous countries dip with more or less declivity as they approach the plains, till they gradually sink under the several strata of those plains, and are at last immerged beyond the reach of miners. This leading fact in the natural history of the earth has been observed by a sagacious philosopher, Mr. Mitchell, in his Conjectures concerning Earthquakes, &c. Philos. Transf. 1760.

That the inferior strata of the earth contain large quantities of pyritous, sulphureous, and metalliferous matters, appears, 1. From the subterranean fires in those inferior strata, which produce volcanos, and probably earthquakes (as Mr. Mitchell ingeniously conjectures). 2. From the observation, that all kinds of mountains are not equally metalliferous; but that veins, especially, are only found in those mountains, which, being composed of very ancient strata; are called primæval, which form the chains and extensive ridges on the surface of the earth, which direct the course of the waters, and which consist of certain strata, the thickness of each of which, its genuine qualities, and its position relatively to the other strata, are, in different parts of the chain of mountains where that stratum is found, nearly uniform and alike, notwithstanding that the numbers, and the inclinations of the strata composing contiguous mountains, or even different parts of the same mountain, are often very various; and therefore that veins are seldom, if ever, found in the mountains called by authors diluvial and temporary, which are single, or detached, which consist not of strata uniformly disposed, but of alluvial masses, in which fragments of ores may be sometimes, but veins never, found. Nevertheless, single, and seemingly detached, mountains in small islands have sometimes been found to be metalliferous. But we must observe, that these mountains consist of uniform strata; that islands themselves, especially small islands, may be considered as eminent parts of submarine ranges of mountains; and that the mountains of such islands may be considered as apices or tops only of inferior mountains.

Those mountains are said to be most metalliferous which have a gentle ascent, a moderate height, and a broad basis, the strata of which are nearly horizontal, and not much broken and disjointed. In these mountains, at least, the veins are less interrupted, more extended, and consequently more valuable to miners than the veins in lofty, scraggy, irregular, and shattered mountains.

Authors dispute concerning the time in which ores have been formed, some referring it to the creation of the world, or to the first subsequent ages; and others believing, that they have been gradually from all times, and are now daily, forming. From the accretion of ores and of their matrices to their proper rocks, and from the insertion of metalliferous nodules and stræ in the hardest stones, it seems most probable, that the matter of those veins and nodules is nearly coeval with the rocks and stones in which they are enveloped. Nevertheless, it cannot be doubted but that small quantities, at least, of ores are still daily formed in veins, fissures, and other subterranean cavities. Several well attested instances confirming this opinion are adduced by authors: Cronstedt mentions an incrustation of silver ore that was found adhering to a thin coat of lamp-black, or of foot, with which the smoke of a torch had soiled a rock in a mine at Koningsberg, in Norway; and that this incrustation of silver ore has been formed by a metalliferous water passing over the rock. Lehman affirms, that he possesses some silver ore attached to the step of a ladder, found in a mine in the Hartz, which had been abandoned two hundred years ago; and that several steps of ladders similarly incrustated had been found. Many other instances are mentioned by authors, of galena, pyrites, silver ores, and other metalliferous substances having been found adhering to wood, to fossil-coal, to stalactitical incrustations, to oyster shells, and other recent substances. From these, and from similar instances, it seems probable, that not only ochres and fragments of ores may, with other alluvial matters, be now daily deposited, but also that small quantities of mineralised ores are recently formed; although many histories mentioned by Becker, Barba, Henckel, and other authors, of the entire renovation of exhausted veins, and especially those of the growth and vegetation of metals and of ores, appear to be at least doubtful.

Various opinions have been published concerning the formation of mineralized ores. According to some, these ores were formed by congelation of the fluid masses found in mines, called gurhs. Other authors believe, that ores have been formed by the condensation of certain mineral, metallic, sulphureous, and arsenical vapours, with which they suppose that mines abound. Some have even affirmed, that they have seen this vapour condense, and become in a few days changed into gold, silver, and other metallic matters. It has been above observed, that from several appearances which occur in veins, there is great reason to believe, that ores have not been carried thither and deposited in their present state, but have been there concreted and crystallized, that is, changed from a fluid to a solid state. But the fluidity of the metalliferous matters at the time of their entrance into veins may have been occasioned either by their having been dissolved in water, if they were capable of such solution, or by their having been raised in form of vapour by subterranean fires. For the disposition to crystallize is acquired by every homogeneous substance that is fluid, whether it has received its fluidity by being melted by fire, or by being dissolved in a liquid menstruum, or by being reduced to the state of vapour. Thus, crystals of sulphur have been observed to be daily formed by the sulphureous vapours which exhale in the neighbourhood of volcanoes. The volatility of the two mineralizing substances, sulphur and
arsenic,

arsenic, and the power which volatile bodies possess of elevating a certain portion of any fixed matter which happens to be united with them, render it probable, that the greatest part at least of mineralized ores have been formed of vapours exhaled from subterranean fires, through the cracks in the intervening strata, occasioned by those earthquakes which have, in a singular manner, broken and de-ranked the strata of metalliferous countries, and which, as has been above remarked, have been probably occasioned by, at least have certainly been always accompanied with, subterraneous fire.

ORES OF ANTIMONY. Antimony has been found in the native state of a silver colour, and its texture composed of moderately large, shining plates, resembling the regulus of antimony of commerce. It has the same habitudes in acids, and aqua regia more particularly dissolves it very well. The solution does not lose its transparency in the cold. Alkalis throw down a white precipitate. The Prussian alkali affords a green precipitate with small blue specks, which shews the presence of iron. In the fire, native antimony melts and is volatilized in white flowers; but a substance of a fat and oily appearance is formed round the fused metal in much greater abundance than with the pure regulus. Mongez asserts, that this is the calx converted into glass of antimony. On the first impression of the heat, a slight smell of arsenic is emitted, which quickly disappears. M. Sage, in fact, found sixteen per cent. of arsenic in the native regulus from Allemont, in Dauphiny. If this native ore be fused in a crucible without any reducing matter, a very neat button is obtained, susceptible of crystallization, more brilliant and clear in its fracture, which exhibits larger plates than before.

The appearances of this native metal, before the blow-pipe, correspond with those observed in the larger process. It evaporates in smoke with a smell of garlic; a white powder is deposited on the charcoal, of which the arsenical portion becomes black and fixed, on application of the interior cone of the flame. The fluxes acquire a faint hyacinth tinge.

Mongez likewise acquaints us with a native calx of antimony, observed by him, upon a piece of the native regulus from Chalangez, in Dauphiny. It is usually crystallized in very white, slender needles, in some portions confused with the plates of the antimony, and in others, radiated from a centre exactly like the crystallized zeolite. These did not contain arsenic.

The most common and abundant ore of antimony is known in commerce simply by the name of antimony, and consists of the ore in combination with sulphur. It is composed of filaments, or needles, adherent to each other, either parallel, or divergent from a centre. These are friable, brilliant, usually of a shining metallic bluish-gray colour; sometimes of a lively chatoyant appearance, according to Mongez; but I think on recollection, not having a specimen of the sort before me, that these colours, though variegated, do not change their position with the eye of the observer, or at least exhibit none of that internal appearance denoted by the word chatoyant. They should therefore rather be called iridescent.

When this ore of antimony possesses a less determined internal structure, it may be mistaken for the small grained lead ore, or white silver ore, or iron glimmer; but it may be distinguished by the smell of sulphur it exhibits when broken or rubbed, and still more effectually by its fusibility, which is such that it runs in the flame of a candle. The sulphur may be easily separated, and its quantity ascertained by aqua regia, which dissolves the metal, and leaves the

sulphur floating at the surface. The aqua regia, according to Kirwan, ought to consist of one part nitrous, and four marine acid.

The specific gravity of this ore of antimony is for the most part from 4,000 to 4,200, and after fusion from 4,700 to 5,000. There are several varieties : 1. The gray striated ore of antimony. 2. Plumous ore of antimony. This has the form of small, silky, gray or blueish filaments, almost always efflorescent. There are some specimens of a deep red, and of a pulverulent reddish colour, in prisms efflorescent upon the gray ore. The ore from Tuscany is of this kind. M. Sage considers the red plumous ore of antimony as a native golden sulphur, and the pulverulent reddish ore as a native kermes mineral. 3. The solid gray ore of antimony. This is a uniform mass of the colour of polished iron or lead, very brittle, and its fracture exhibits small brilliant facets, and sometimes filaments. It melts and is volatilized by the flame of a candle.

The sulphureous ore of antimony urged by the flame of the blow-pipe is liquefied, flows on the charcoal, soaks into it, and at length entirely disappears, except a portion of flowers, which are deposited circularly. One hundred parts of the ore contain twenty-four parts of the regulus slightly calcined, and twenty-six of sulphur. For the analysis in the dry way, see ANTIMONY.

The red ore of antimony has the same texture with the common sulphureous ore, but its fibres are not so coarse. Almost all antimonial ores contain arsenic, but the proportion in this is more abundant. Wallerius distinguishes three varieties found in Hungary and Saxony, viz. the red, the violet, and the pale red.

ORES OF ARSENIC. Arsenic is found native in Saxony, Bohemia, Hungary, and elsewhere, but particularly at St. Marie aux Mines in Alsatia. It is often found of no determinate figure, friable, and pulverulent; but sometimes compact, divided into thick, convex plates, with a needle-formed or micaceous surface. It is of a lead colour when fresh broken, and may be cut with a knife, like compact black lead, but soon blackens by exposure to the air. In hardness it seems to exceed copper, but is brittle like antimony. It burns with a small flame, and goes off in smoke. Cronstedt says nothing of the residue, but Bergman remarks that he never found native arsenic without iron.

Native arsenic before the blow-pipe takes fire emits a white smoke, covers the charcoal with flowers of arsenic, which quickly become black. A strong smell of garlic is emitted. If the portion of iron it contains be considerable, it remains on the coal; if not, it disappears. It communicates a yellowish colour to the flux, which disappears in proportion as the arsenic is volatilized.

Calcsiform arsenic is in general scarce. It is either in a loose or powdery form, or else in white semi-transparent crystals. Like the artificial calx, it is volatilized by heat, emitting a smell of garlic, and possesses the same solubility in water. See ARSENIC. It does not detonate with nitre, though an effervescence arises. It is scarcely soluble in the vitriolic acid, something more in the marine, but most perfectly in the diluted nitrous acid. Before the blow-pipe, it evaporates in white flowers, which cover the charcoal. The peculiar smell of garlic appears to be sufficiently distinctive of this semi-metal; but Mongez observes, as the characteristic marks of the respective flowers of arsenic, antimony, and zinc, that the first, when distributed upon the charcoal, become suddenly black if touched with the interior part of the flame, the second remain white, and the third become yellow.

The combinations of arsenic with sulphur are either *orpiment* or *realgar*. These are also produced by art. See the words. Native orpiment is of a

yellow

yellow colour, inclining to red in some specimens, and green in others. It is frequently mixed with yellow mica and spar, which cause it to appear as if compounded of facets of greater or less magnitude. In the fire its colour becomes obscure, a white bluish flame appears, with a considerable mixed smell of garlic and sulphur. By an open fire it is almost entirely volatilized, and leaves only a greenish earthy residue; but in a close vessel it melts, and in cooling becomes the reddish mass called realgar. It is easily distinguished from artificial orpiment, because its figure is almost always that of small, silky, light crystals, or granulated.

Native realgar has got a more lively colour, and possesses every degree of transparency, from that of the clear red crystals, called the ruby of arsenic, which is compact and hard, to that of perfect opacity. Its habitudes before the blow-pipe are the same as those of orpiment.

Bergman's method of analysing these ores consists in digesting them in marine acid, adding the nitrous by degrees, to help the solution. The sulphur will be found on the filtre, and the arsenic will remain in the solution, from which it may be precipitated in its metallic form, by zinc, adding spirit of wine to the solution.

Arsenical ores, containing the other metals, are in general distinguished by their respective denominations. The arsenical pyrites, or marcasite, contains sulphur and iron. It is of a gray ash colour, inclining to blue, either solid or composed of small brilliant particles. It tarnishes in the air, gives fire with steel, and emits a smell of garlic. Sometimes it effervesces with the nitrous acid, which partly dissolves it. In the fire it is volatilized, and forms a true realgar, which distinguishes it from mispickel, which contains iron and acid without sulphur, and might easily be confounded with it. See MISPICKEL, also ARSENIC.

ORES OF BISMUTH. Bismuth is the most common of all native metallic substances. It is generally found either in cubes or octagons, or of a dendritical form, or else in thin lamina investing the ores of other metals, particularly those of cobalt. As it is very fusible, it may easily be extracted by exposing the minerals which contain it to a gentle heat. It then exudes in small white globules, the more readily in proportion to its purity. It effervesces with nitrous acid, forming a solution at first milky, but which afterwards becomes clear. It is said to be sometimes alloyed with silver, in which case, a separation may easily be made, by adding water to the nitrous solution, which throws down the bismuth in the form of magistery.

Calceiform bismuth is found of a whitish or greenish-yellow colour, frequently upon the other ores of bismuth, probably formed by decomposition. It is then called flowers of bismuth, and may be distinguished from the flowers of cobalt by the red colour of the latter; for the flowers of bismuth are never red, nor become so. This calx is readily dissolved in nitrous acid, and a bismuth may be precipitated by water.

The calx of bismuth is reducible on the charcoal by the blow-pipe, and melts in the spoon. With microcosmic salt it affords a globule of a dull yellow colour, which becomes paler and rather more opaque by cooling. With borax, a mass is obtained in the spoon which is gray upon the charcoal, and not easily cleared of small bubbles. This glass fumes when kept in a state of fusion, and forms a circle of a greenish-yellow colour around it, produced by the volatilization of part of the bismuth.

Bismuth is mineralized by sulphur. It resembles galena or potters' lead ore in colour and appearance, is brittle, easily cut with a knife, and does not effervesce

with

with acids, though soluble in aqua fortis. The solution is clear, and sometimes greenish. It is said to contain also cobalt and arsenic, but Mongez denies the latter. It is very fusible, and the sulphur mostly separates in scorification. There are two varieties; the one tessular like galena, from Bastanes in Sweden, and Schneeberg in Saxony, which is very scarce; the other striated, composed of scales or small needles, like the sulphureous ore of antimony, but does not soil the fingers. It comes from Schneeberg and John-Gorgenstadt in Saxony.

Before the blow-pipe this ore speedily melts, and affords a blue flame with a smell of sulphur, but the perfect reduction is rather long and difficult. Bergman advises to precipitate the bismuth with a small quantity of cobalt, which penetrates the globule by virtue of the sulphur. The mass then swells up, and produces a scoria divided into very evident compartments. This scoria, kept a longer time in the fire, emits globules of bismuth.

Bismuth is also found mineralized with sulphur and iron. This ore is composed of small, thick, uniform scales, of a gray-yellowish colour when recently broken, but more yellow where it has suffered exposure to the air. This species is more difficult to reduce than the preceding, on account of the iron it contains.

Wallerius, Sage, and Romé de Lisle, mention an ore of bismuth mineralized with sulphur and arsenic, which is of a shining appearance, of a whitish-yellow, or ash colour, composed of scales, in general small, hard, sometimes giving fire with a steel, not effervescent with nitrous acid, though partly soluble. Mongez is disposed to think it merely the sulphureous ore of bismuth, already mentioned, but observes that the presence of arsenic cannot but shew itself by its peculiar smell when heated. See BISMUTH.

ORES OF COBALT. Cobalt has not been found in a state of native purity, but the combination of this semi-metal with arsenic and iron in the metallic form usually passes for such. The quantity of iron is small. This ore is solid, hard, ponderous, of a gray colour, more or less obscure, sometimes inclining to red. Its fracture is granulated, not unlike some kinds of steel. It commonly gives fire with the steel, and emits a strong smell of garlic. In the fire it becomes black. Nitrous acid dissolves it with effervescence, which affords a sympathetic ink by the addition of marine acid. There are two characters which readily distinguish this mineral from the white and gray ores of arsenic. 1. It forms a sympathetic ink with aqua regia; and 2. It affords a blue glass with borax, whereas that of the ore of arsenic is black. There are two varieties, the one solid and compact, the other granulated and easily broken, besides that its colour is of a reddish-white, and sometimes a little hepatic.

Before the blow-pipe this ore first emits a strong smell of garlic, then becomes black, and melts into a small globule of the regulus. It gives a blue colour to the fluxes.

The calciform cobalt is commonly found in the earth mixed with arsenic, iron, or copper; but whether mechanically, or more intimately combined, is doubted by Bergman. It is usually of a gray-black, but sometimes so black that it might be taken for soot. It soils the fingers, and is almost always friable and pulverulent. On breaking a compact specimen, rose-coloured spots may frequently be observed, resembling the flowers of cobalt. It is seldom without a mixture of a small portion of calx of iron. When solid, it sometimes has the resemblance and form of a vitreous scoria, whence some mineralogists have called it the vitreous ore of cobalt or slag. These are free from sulphur and arsenic. Cronstedt compares the friable ore, or cobalt ore, to the artificial zaffre. Mongez says it contains clay.

Before the blow-pipe, as the black calx of cobalt is always mixed with a small portion of the red calx which is arsenical, it emits a slight smell of garlic. The reduction is very difficult. But it dissolves in borax, gives it a blue colour, and is partly reduced in a small metallic globule, which occupies the lower part of the flux.

ORES OF COPPER. Copper is not, according to the opinion of Bergman, found native without a mixture of gold, silver, or iron. Some specimens, however, nearly resemble the refined copper in colour, malleability, and ductility. Others, instead of possessing the reddish colour, are rather of a yellow or brown colour, with green or blue spots of rust. It is found in two different forms: 1. Solid native copper, which is either crystallized or in grains, or thin leaves, threads or dendrites adherent to different matrixes, such as calcareous stones, spars, quartz, petro-felix, jasper, schistus. There are few copper ores, according to Mongez, which do not contain some of these varieties. 2. Native copper in the form of small or imperfectly coherent grains. This copper appears to have been deposited from vitriolic waters by means of iron, for which reason it is called cement copper.

Kirwan directs the humid assay of native copper by nitrous acid. The gold, if it contains any, remains undissolved in the form of a black powder, which may be taken up and examined by aqua regia. The silver may be precipitated from the nitrous solution by marine acid, or better by copper, and the iron falls down in the form of an insoluble calx by sufficient ebullition with water.

The calciform copper ores are either of a red, blue, or green colour.

The red copper ore is rather scarce. In some specimens it is of a beautiful red, or of a brown-reddish liver colour, whence it has obtained the name of hepatic ore. When in a loose form it is called copper ore; but generally it is moderately hard, though brittle, sometimes crystallized and transparent, either in a capillary form, or in cubes, prisms, or pyramids. Mongez says, that the most common form is that of fine grains resembling the flowers of cinnabar. It is easily distinguished by its brightness and ruddy colour, which approaches that of copper. It effervesces with acids, which dissolve it as well as the other calciform ores of copper. Another common character of these ores is, that they blacken in a moderate heat, to which may be added, the property of affording a blue colour with the volatile alkali.

According to Fontana, quoted by Kirwan, a hundred parts of this ore contain seventy-three of copper, twenty-six of fixed air, and one of water. Bergman also found it to contain fixed air. The brown or hepatic ore contains a variable proportion of iron or pyrites, and sometimes sulphurated copper, and hence affords from 20 to 50 per cent. of copper. It is often iridescent.

The blue calciform copper ore most frequently appears in a loose form, though sometimes indurated and even crystallized, but it is then mixed with quartz. It frequently lines the internal cavities of different matrixes. When the blue colour is very lively, it is called azure of copper, when paler, mountain blue, and when abounding with earthy matter, blue chryfocolla. It must be confessed however, that these terms are by no means accurately applied, but taken for the most part indiscriminately. Morveau, in *Memoirs of Dijon*, has inferred from experiment, that the calces of copper are determined to a blue rather than to a green by a nearer approach to the metallic state; but on this head see VERDITER.

The green copper ore is distinguished by the names mountain green, or green chryfocolla. It is found in two states, either earthy and friable, of a more or less deep

deep green, or else solid and crystallized. The most beautiful specimen is the silky copper ore, so called because its texture exhibits long shining filaments.

The solid green ore is usually called malachite. See MOUNTAIN GREEN, MOUNTAIN BLUE, and MALACHITE.

Analogous to the calciform copper ores, are the lapis armenus, and the turquoise, the former of which is a blue stone, that does not admit of a polish, and consists of calcareous earth or gypsum, penetrated with the blue calx of copper; hence it sometimes effervesces with acids, and sometimes not; but never gives fire with steel. It loses its colour when well heated in the fire. This stone is very different from the lapis lazuli, since this last contains no copper. See LAPIS LAZULI.

The turquoise appears to be the tooth of an animal, penetrated with the blue calx of copper. It loses its colour when over-heated. It is opaque, of a lamellar texture, and susceptible of a fine polish.

Its specific gravity is from 2,5 to 2,908. Some are of a deep blue, some of a whitish blue, but become of a deeper when heated. These stones are found in Persia and in Turkey, from whence they received their name. But they are also found in Lower Languedoc, in France, near the village Simere, where these stones, when dug out from the mine, resemble different bones, teeth, &c. of various sizes; and are whitish, grey, or yellowish. They receive the blue colour on being slowly heated to a high degree; but if the fire be long continued afterwards, the colour is irrecoverably lost.

Jewellers divide this kind of stones, or rather bony substances, according to their fanciful method, into oriental and occidental turquoises (see ORIENTAL); ranging the hardest and the finest coloured under the first epithet; and the softest, or of an inferior colour, under the second denomination. But, although experience shews the fallacy of such distinctions in a great many instances, the old custom continues nevertheless to prevail.

According to Kirwan, the blue coppery tincture of the turquoises may be extracted from them by distilled vinegar: and Reaumur asserts, that nitrous acid will not dissolve the Persian turquoises, though it will those of France; which, if true, indicates a real difference between them.

Bergman from Werner mentions a copper ore, consisting of that metal mineralized by fixed air, and combined with clay. This is most commonly superficial in small crystals of a beautiful green, or in small scales, and was formerly considered as a variety of mica or talc. Nitrous acid dissolves it very well, and the solution takes a green colour. The copper may be precipitated in the usual manner. The blow-pipe does not fuse this ore, if the flame be directed against its flat surface; but if the edge be attacked, it speedily melts into a black scoria. With borax it affords a brown yellow glass, and with microcosmic salt a glass of a fine grass green.

Copper mineralized by sulphur is commonly denominated the vitreous copper ore. Its colour is red, brown, blue or violet; it is generally so soft as to be cut with a knife, and shews a polished gold-coloured surface where cut. As to form, it is sometimes crystallized in regular figures, and sometimes irregular. In its fracture it often shews violet, reddish and variable colours. It is much more fusible than pure copper, and may even be melted by a candle. Its specific gravity is from 2,81 to 5,338. It is found in the mines of other copper ores, and in lime-stone, spar, quartz, mica, and clay; it is the richest of all the copper ores, and affords from 80 to 90 per cent. of copper, 10 or 12 of sulphur, with a small proportion of iron; the red ores are the poorest, containing most iron.

This

This ore may be reduced with considerable facility by the blow-pipe, but it is not easy to scorify and separate the last portions of iron and sulphur. To analyse the ore, Mr. Bergman advises a solution of it in five times its weight of concentrated vitriolic acid by ebullition to dryness, and the subsequent addition of as much water as will dissolve the vitriol thus formed. This solution he precipitates by a clean bar of iron, and thus obtains the copper in its metallic form. If the solution be contaminated with iron, he re-dissolves the impure copper thus obtained, in the same manner, and so procures a richer solution; which he again precipitates with iron.

The azure copper ore differs from the vitreous ore only in containing more iron, of which the proportion is from 20 to 50 per cent. Its colour consists of various shades of blue, or reddish blue. It is as hard or harder than the preceding, and its fracture is reddish and polished like glass. It is more difficultly reduced by the blow-pipe, and may be analysed in the humid way by the same treatment.

The yellow copper ore, or copper pyrites, contains a large proportion of iron mineralized with sulphur. It is sometimes found crystallized, and sometimes irregularly formed. The crystallized sort contains the smallest portion of copper, which is sometimes so trifling that the ore may be considered as a martial pyrites, though an experienced eye may discern a difference between them. The copper scarcely exceeds 40 per cent. in any of the specimens. When this metal is sufficiently abundant to be wrought with profit, it may be roasted, and the sulphur preserved towards defraying the expences. The residue being exposed to the united action of air and water, in a proper situation will afford the vitriol of copper, which may either be crystallized for sale, or precipitated by fragments of old iron, as is advantageously done at the Paris-mountain mine in the isle of Anglesea, and elsewhere. When rich in copper, it is of a brilliant yellow colour, sometimes approaching to red; in other samples it is greenish, from the admixture of these two colours. The colours are more neat and lively at the place of fracture, than after exposure to the air, which changes them. It is not very hard, is considerably brittle, and scarcely gives fire with the steel. Its friability is greater, the larger the proportion of sulphur, and the less of iron. It affords several varieties: 1. Yellow copper ore, which is solid, ponderous, brilliant, and close in its fracture. 2. The yellow ore, which though hard, has a laminated fracture; this is the most common of any. 3. Green yellowish copper ore; it contains the largest portion of sulphur, and the least of iron. 4. Crystallized yellow copper ore; it is the copper pyrites, properly so called, containing the least proportion of copper and the most of iron. When this is met with among rich ores, it is thrown aside because of its difficult reduction and small produce, which does not exceed four or five pounds of copper in the hundred weight of ore. Its colour varies, being sometimes reddish, or resembling a pigeon's neck; when yellow, it is paler than the first variety here mentioned. The management of this ore in the analysis may be gathered from what has already been said. It may readily be fused by the blow-pipe into a black matt, but it requires a continuance of the heat for a long time before the globule of copper becomes disengaged.

The grey copper ore appears to owe its character to arsenic, which exists in it together with iron and sulphur. It sometimes contains silver. The copper amounts to between 35 and 60 parts in the hundred.

The colour of this ore is an obscure or blackish grey: it is hard; and the
4 C
arsenic

arsenic it contains renders it brittle. In its external appearance it greatly resembles the vitreous ore of copper, but its colour is less bright, and inclines to yellowish: it is not easily cut with a knife, and in particular it does not take the shining face exhibited by the vitreous ore when cut. It is likewise less rich, and more difficult of reduction. It might with more facility be confounded with the grey silver ore, or fahlerts; but Mongez remarks that these may be distinguished from their scrapings or powder, which is red in the grey silver ore, but grey in the copper ore. Some pieces of this ore contain no silver at all, but in general these two ores differ only in the quantity of silver and copper they respectively contain. If the product of silver exceed one or two per cent. it is called grey silver ore, according to Kirwan. Monnet distinguishes three varieties: 1. Grey copper ore, improperly called vitreous, of a poppy colour: this is the richest. 2. Very hard copper ore, of which abundance is found in the Hartz. 3. Grey copper ore of the colour of bronze: this is the poorest and most arsenical.

In the treatment of these ores with the blow-pipe, the arsenic evaporates; and if after the first fusion the small globule be suffered to cool before all the arsenic is evaporated, brown black flowers crystallize all round the globule. The calcination must be continued until the globule sparkles, and exhibits the metallic brilliancy of fused copper.

The blende copper ore contains, according to Kirwan, pyrites, blende, and from 18 to 30 per cent. of copper. It is of a brown colour, and of a hard, solid, compact, granular texture. The analysis in the humid way is rather complicated. The metals are taken up by nitrous acid, and the copper precipitated by iron. The iron and zinc are then to be precipitated from the decanted solution by Prussian alkali. This compound precipitate must be exposed to a calcining heat, then re-dissolved in nitrous acid, and the fluid evaporated to dryness. These last processes completely calcine the iron, so that a third application of nitrous acid will dissolve the zinc only. The quantity of this last metal may be known by a second precipitation by the Prussian alkali. One hundred grains of this precipitate, washed and dried, are equivalent to 20 of zinc in its metallic state; and 100 grains of the calcined iron are equivalent to 73 and a half in the metallic state.

M. Sage, quoted by Mongez, mentions an antimonal copper ore containing arsenic and sulphur as the mineralizer. This ore is grey like crude antimony, brilliant in its fracture, and susceptible of a blue and green efflorescence. From the analysis of this chemist, it contains 20 pounds of copper in the quintal, but according to that of M. Chabcaussiere, no more than 14. It exhibits the remarkable phenomenon, that it easily enters into fusion, but is very long before it is decomposed by the fire: this circumstance, no doubt, arises from the antimony it contains.

The schistose, or slaty copper ore, consists of the yellow or green copper ores, the pure calces, mountain blue, and other varieties, dispersed through slate as the matrix, according to Mongez. But Kirwan thinks it consists of the vitreous copper ore, intimately combined with schistus, and not barely dispersed through it in visible particles. It is of a brown or black colour, of a lamellar texture, and very heavy. It affords from six to 10 per cent. of copper, and is of difficult fusion, unless lime stone be added. It contains a little bitumen, calcareous earth, and iron, as schists do.

There is a bituminous copper ore, or pit-coal containing copper, which is found in Sweden, Hungary, and Alsatia. It takes fire without much difficulty, burns

burns slowly, and leaves ashes, from which copper is extracted. This is probably the same substance mentioned by Brunnich on Cronstedt, p. 668, which is called pitch-ore, in the Bannat of Temeswar. Gellert, in his Metallurgic Chemistry, mentions a copper ore of the colour of pitch, which resembles a vitrified scoria, and Raspe informs us that copper has been found in Cornwall mixed with black pitchy rock oil.

Copper is also obtained from waters in which it is combined with the vitriolic, and sometimes marine acid, no doubt produced by the decomposition of some of the ores above mentioned. Animal and vegetable substances are sometimes found penetrated with copper.

I shall conclude this article by inserting some processes for the reduction of copper ores in the furnace, taken from Cramer.

PROCESS I.

(Cramer's Art of Assaying, process 36.)

To reduce and precipitate copper from a pure and fusible ore in a close vessel.

Mix one, or, if you have small weights, two docimastical centners of ore, beaten extremely fine, with six centners of the black flux; and having put them into a crucible or pot, cover them one inch high with common salt, and press them down with your finger: but let the capacity of the vessel be such, that it may be only half full; shut the vessel close, put it into the furnace, heap coals upon it so that it may be covered over with them a few inches high; govern the fire in such a manner, that it may first grow slightly red hot; soon after you will hear the common salt crackle, which will be followed by a gentle hissing noise. As long as this lasts, keep the same degree of fire till it ceases. Then suddenly increase the fire, either with the funnel and cover put upon the furnace, or with a pair of bellows applied to the hole of the bottom part, that the vessel may become strongly ignited. Thus you will reduce and precipitate your copper in about a quarter of an hour: then take out the vessel, and strike with a few blows the pavement upon which you put it, that all the small grains of copper may be collected into one mass.

Break the vessel, when grown cold, in two, from top to bottom, as nearly as you can: if the whole process has been well performed, you will find a solid, perfectly yellow, and malleable regulus adhering to the bottom of the vessel, with scorias remaining at top of a brown colour, solid, hard, and shining, from which the regulus must be separated by several gentle blows of a hammer: when this is done, weigh it, after having wiped off all the impurities.

A soft, dusty, and very black scoria is a sign the fire was not sufficiently strong. Small neat grains of copper reduced, but not precipitated, and adhering still to scorias, especially not very far from the bottom, and an unequal and ramified regulus, are signs of the same thing. A solid, hard, shining, red-coloured scoria, especially about the regulus, or even the regulus itself, when coloured with a like small crust, are signs of an excess in the degree and duration of the fire.

Remarks. All the ores which are easily melted in the fire are not the objects of this process; for they must also be very pure. Such are the vitreous copper ores; but especially the green and azure-coloured ores, and the caruleum and viride montanum, which are not very different from them. But if there is a great quantity of arsenic, sulphur, or of the ore of another metal and semi-metal, joined to the ore of copper, then you will never obtain a malleable regulus of pure copper, though ores are not always rendered refractory by the presence of these.

PROCESS II.

(Cramer, process 37.)

To reduce and precipitate copper out of ores rendered refractory by earth and stones that cannot be washed off.

Beat your ore into a most subtle powder, of which weigh one or two centners, and mix as much sandiver with them. This done, add four times as much of the black flux with respect to the ore; for by this means the infusible terrestrial parts are better disposed to scorification, and the reducing flux may act more freely upon the metallic particles, set at liberty.

As for the rest, proceed as in the last process: but you must make the fire a little stronger for about half an hour together. When the vessel is grown cold and broken, examine the scorias, whether they are in the state they ought to be. The regulus will be as fine and ductile as the foregoing.

Remark. As these copper ores contain scarcely any sulphur or arsenic, the roasting would be of no effect, and much copper would be lost. For no metallic calx, except those of gold and silver, improperly so called, can be roasted without some loss of the metal.

PROCESS III.

(Cramer, process 38.)

To precipitate copper out of an ore that contains iron.*

Act in every respect according to the last process. But you will find, after the vessel is broken, a regulus by no means so fine, but less ductile, wherein the genuine colour of the copper does not perfectly appear, and which must be further purified.

Remarks. The fire used in this operation is not so strong as to reduce and fuse iron alone. But copper dissolves iron in the dry way, though of itself very refractory in the fire. And for this reason, while the ore and the flux are most intimately mixed and confounded by trituration, the greatest part of the iron will combine with the copper in its metallic state.

PROCESS IV.

(Cramer, process 39.)

The roasting of pyritose, sulphureous, arsenical, semi-metallic copper ore.

Break two docimaistical centners of the ore to a coarse powder, put them into a test covered with a tile, and place them under the muffle of a docimaistical furnace. The fire must be so gentle, that the muffle may be but faintly red-hot: when the ore has decrepitated, open the test, and continue the fire for a few minutes; then increase it by degrees, that you may see the ore perpetually smoking a little: in the mean time, it is also proper now and then to stir it up with an iron hook. The shining particles will assume a dark red or blackish colour. This done, take out the test, and let it grow cold. If the small grains are not melted, nor strongly adherent to each other, the process has been well conducted; but if they run again into one single cake, it must be repeated with another portion of the ore, in a more gentle fire.

When the ore is grown cold, beat it to a powder somewhat finer, and roast it by the same method as before; then take it out, and if the powder is not yet melted, beat it again to a most subtle powder; in this you are to take care that nothing be lost.

* Cramer still means the calciform ores only, and not the mineralized ores of copper.

Roast the powder in a fire somewhat stronger, but for a few minutes only. If you do not then find the ore in any respect inclined to melt, add a little tallow, and burn it away under the muffle, and repeat the operation till the fire being very bright, you no longer perceive any sulphureous, arsenical, unpleasant smell, or any smoke; and there remains nothing but a fine soft powder of a dark red, or blackish colour.

Remarks. Every pyrites contains iron, with an unmetallic earth, with sulphur, or arsenic, and most commonly both. Besides, as the copper in pyrites is exceedingly variable in quantity, their disposition in the fire must vary accordingly. For instance, the more copper there is in pyrites, the more it inclines to colligation. The more sulphur and arsenic it contains, the more fusible it will be; and the more iron and unmetallic earth it contains, the more refractory it will prove in the fire. If such pyrites melt in the roasting, as is the case with some of them, or if they grow but red hot, the sulphur and arsenic become so strictly united to the fixed part, that it is almost impossible to dissipate them. For in this case, when the matter is again reduced into a powder, a much greater time and accuracy are required in the management of the fire to perform the operation. For this reason, it is much better to repeat it with new pyrites. But you must roast no more than twice the quantity at once of the ore you are inclined to employ in the foregoing experiment; in order that, if the precipitation by fusion should not succeed, there may still remain another portion for use, instead of your being obliged to repeat a tedious roasting. If you observe the signs of a ferruginous refractory pyrites, the operation must be performed with a stronger fire, and with much greater speed. However, you must be careful not to perform it with too violent a fire: for a large proportion of copper is destroyed not only by the arsenic, but by the sulphur; and this happens even in vessels nearly closed, when the sulphur is expelled by a fire not quite so strong. By repeated and gentle sublimation of the sulphur in a vessel, both very clean and well closed, this fact will be clearly seen.

When the greatest part of the sulphur and the arsenic is dissipated, you may make a stronger fire: but then it is proper to add a little fat. Cramer here accounts for the advantage produced by the fat, by observing, that it dissolves mineral sulphur. In fact, it reduces and volatilizes the last portions of arsenic, and at the same time, as he justly remarks, prevents that extreme scorification of the copper which would greatly impede its subsequent reduction. Hence he adds, the reason is plain, why assayers produce less metal in the trying of veins of copper, lead, and tin, than skilful smelters do in large operations. For the former perform the roasting under a muffle, with a clear fire, and without any oily reducing matter; whereas the latter perform it in the middle of charcoal or of wood, which constantly tend to reduce the calces.

The darker and blacker the powder of the roasted ore appears, the more copper you may expect from it. But the redder it looks, the less copper and the more iron it affords; for roasted copper dissolved by sulphur, or the acid of it, is very black; and iron, on the contrary, very red.

PROCESS V.

(Cramer, process 40.)

The precipitation of copper out of roasted ore of the last process.

Divide the roasted ore into two parts, and reckon each of them a centner: add to it the same weight of sandiver, and four times as much of the black flux, and

and mix them well together. Manage the rest of the operation in every respect according to process 1. The precipitated regulus will be slightly malleable, sometimes brittle, now and then very much like pure copper in its colour, but sometimes whitish, and even blackish. Whence it is most commonly called black copper, though it is not always of so dark a colour.

It is easy to conceive, that there is as great a difference between the several kinds of the metal called black copper, as there is between the pyritose and other copper ores accidentally mixed with other metallic and semi-metallic bodies. For all the metals, the ores of which are intermixed with the copper ores, being reduced, are precipitated together with the copper; which is brought about by means of the black flux. Hence, iron, lead, tin, the metallic part of antimony, bismuth, are most commonly mixed with black copper in a variety of different proportions. Indeed, it is self-evident, that gold and silver, which are dissolvable by all these matters, are collected in such a regulus, when they have previously existed in the ore. And moreover, sulphur and arsenic are not always entirely absent. For they can hardly be expelled so perfectly, by the many preceding roastings, but there will remain some vestiges of them, which are not dissipated by a sudden melting, especially in a close vessel, wherein the flux swimming at top hinders the action of the air. Indeed, arsenic is rather fixed by the black flux, and assumes a reguline semi-metallic form, while it is at the same time preserved from dissipating by the copper.

PROCESS VI.

(Cramer, process 44.)

To reduce black copper into pure copper by scorification.

Separate a specimen of your black copper, of the weight of two docimaetical centners at least; and perform this in the same manner, and with the same precautions, as if you would detect a quantity of silver in black copper.

Then with lute and coal-dust make a bed in the cavity of a moistened test: when this bed is dry, put it under the muffle of the docimaetical furnace, in the open orifice of which there must be bright burning coals, with which the test must likewise be on all parts surrounded. When the whole is perfectly red-hot, put your copper into the fire alone, if it contains lead; but if it is entirely deprived of it, add a small quantity of glass of lead, and with a pair of hand-bellows increase the fire, that the whole may speedily melt: this done, let the fire be made a little less violent, and such as will be sufficient to keep the metallic mass well melted; and not much greater. The melted mass will boil, and scorias will be produced, that will gather at the circumference. All the heterogeneous matters being at last partly dissipated, and partly turned to scorias, the surface of the pure melted copper will appear. As soon as you perceive this, take the pot out of the fire, and extinguish it in water: then examine it in a balance; and if lead has been at first mixed with your black copper, add to the regulus remaining of the pure copper, one fifteenth part of its weight which the copper has lost by means of the lead; then break it with a vice; and thus you will be able to judge by its colour and malleability, and by the surface of it after it is broken, whether the purifying of it has been well performed, or no. But whatever caution you may use in the performing of this process, the product will notwithstanding be always less in proportion than what you can obtain by a larger operation, provided the copper be well purified in the small trial.

Remarks. This is the last purifying of copper, whereby the separation of the heterogeneous

heterogeneous bodies, begun in the foregoing process, is completed as perfectly as it possibly can be. For, except gold and silver, all the other metals and semi-metals are partly dissipated and partly burnt, together with the sulphur and arsenic. For in the fusion they either turn of themselves to scoria or fumes, or this is performed by means of iron, which chiefly absorbs semi-metals, sulphur, and arsenic, and at the same time they accelerate its destruction. Thus the copper is precipitated out of them pure: for it is self-evident, that the unmetallic earth is expelled, the copper being reduced from a vitrescent terreftrial to a metallic state; and the arsenic being dissipated, by means of which the said earth has been joined to the coarser reguli of the first fusion. But there is at the same time a considerable quantity of the copper that mixes with the scorias, though a great part of it may be reduced out of them by repeating the fusion.

The fire in this process must be applied with all possible speed, to make it soon run: for, if you neglect this, much of your copper is burnt; because copper that is only red-hot cleaves much sooner, and in much greater quantity, into half-scorified scales, than it is diminished in the same time when melted. However, too impetuous a fire, and one much greater than is necessary for its fusion, destroys a much greater quantity of it than a fire only sufficient to fuse it. For this reason, when the purifying is finished, the melted body must be extinguished in water together with the vessel, lest, being already grown hard, it should still remain hot for a while; which must be done very carefully to prevent dangerous explosions.

The scoria of the above process frequently contains copper. To extract which, let two or three decimathical centners of the scoria, if it be charged with sulphur, be beat to a subtile powder, and mix it, either alone, or, if its refractory nature requires it, with some very fusible, common, pounded glass, without a reducing saline flux, and melt it in a close vessel, and in a fire having a draught of air; by which you will obtain a regulus.

But when the scoria has little or no sulphur at all in it, take one centner of it, and with the black flux manage it as you do the fusible copper ore (process I.); by which you will have pure regulus.

PROCESS VII.

The following process is translated from Mr. Gellert's Elements of Essaying*.

To essay copper ores.

Roast a quintal of ore (after the manner described in process IV.); add to it an equal quantity of borax, half a quintal of fusible glass, and a quarter of a quintal of pitch; put the mixture in a crucible, the inner surface of which has been previously rubbed with a fluid paste of charcoal-dust and water; cover the whole with pounded glass mixed with a little borax, or with decrepitated sea salt: put a lid on the crucible, which you will place in an air furnace, or in a blast furnace: when the fire shall have extended to the bottom of the coals, let it be excited briskly during half an hour, that the crucible may be of a brisk red colour: then withdraw the crucible, and when it is cold break it: observe if the scoria be well made: separate the regulus, which ought to be semi-ductile, and weigh it. This regulus is black copper, which must be purified as in process 6:

If the ore be very poor, and enveloped in much earthy and stony matters, to a quintal of it, a quintal and a half of borax, a quarter of a quintal of pitch, and ten pounds of calx of lead or minium, must be added. The calx of lead will be

* Notes to Macquer's Dictionary. Art. ORES.

revived, and will unite with the scattered particles of the copper, and together with these will fall to the bottom of the crucible, forming a compound regulus. When the ores of copper are very rich, half a quintal of borax and a quarter of a quintal of glass will be sufficient for the reduction. If the ore is charged with much antimony, a half or three quarters of a quintal of clean iron filings may be added; otherwise the large quantity of antimony might destroy the copper, especially if the ore contained no lead. If iron be contained in copper ore, as in pyrites, some pounds of antimony, or of its regulus, may be added in the essay; as these substances more readily unite with iron than with copper, and therefore disengage the latter metal from the former.

ORES OF GOLD. From the unchangeableness of gold by the solvents usually disengaged in nature, it is comparatively very seldom found but in the native state. In this state it is never absolutely pure, but always mixed either with silver, copper, or iron. It is usually found in rocks of quartz, always in small particles or masses. The sands of several rivers afford it in small plates or leaves. Most great rivers carry gold with them, even such as do not take their rise in mountains where gold is found. In the south of France, in Transylvania, and elsewhere in Europe, this gold is separated by washing off the sand; but the produce is not sufficient in general to pay any rent, or employ capital. It merely affords subsistence to such poor families as apply to this species of industry, particularly after the torrents occasioned by heavy rains. If a hundred pounds of sand contain twenty-four grains of gold, it is said the separation is worth attending to; but in Africa, five pounds of sand often contain sixty-three grains of gold. The heaviest sand, which is often black or red, yields most.

Daubenton distinguishes eight varieties of native gold. 1. In powder. 2. In grains. 3. In small spangles. 4. In masses. 5. In filaments. 6. In branches like vegetables. 7. In small plates; and 8. In octohedral crystals.

Gold is found mineralized by sulphur together with iron, which is supposed to be the connecting medium. This is the auriferous pyrites. It is close and compact, of a brighter and more lively yellow than the ordinary pyrites; notwithstanding which, they are, as Mongez says, very difficult to be distinguished. The gold cannot be extracted by aqua regia, or by amalgamation, but the last mentioned author gives the following simple method for this purpose: Take a small quantity of this pyrites, and digest it in the nitrous acid. All the foreign matters will be dissolved, except the gold and sulphur, which fall to the bottom. Wash the residue under water till nothing more remains but a yellow brilliant powder. This is the gold. According to M. Sage, one half as much more gold is extracted from the pyrites by this method, than by treatment with lead. This pyrites, according to Cronstedt, sometimes contains an ounce of gold in the hundred pounds. Some samples contain a portion of zinc as well as iron, and even copper, which gives the mass a greenish tinge. It is found at Adelfors in Sweden, in Hungary, Mexico, the island of Sumatra, Switzerland, and Dauphiny in France. Cronstedt remarks, that no pyrites ought to be despised, which are found in tracts where gold ores are obtained. Brunnich on Cronstedt affirms that the Transylvanian gold pyrites, in which no gold can be discovered by the eye, contained from fifty to one hundred and ten ounces, and upwards, in the hundred weight: and that those where the gold appears in the pyrites like mixed Spanish snuff, contained two hundred and fifty ounces, but they are very scarce.

Gold is found in Hungary united with mercury and sulphur. It is the auriferous cinnabar.

There is likewise a blend of ore of zinc found at Chemnitz in Hungary, which contains silver and gold. It is usually of a red or black colour.

The auriferous ore of Nagayac in Transylvania is mentioned by Bergman as a compound of gold, silver, lead, and iron, mineralized by sulphur. Sage, quoted by Mongez, remarks, that there are few ores which contain so numerous an assemblage of metallic matters. For it includes the red foliated and transparent blend, the specular ore of antimony, copper, silver, and iron. This ore is of a gray colour, more or less obscure, in irregular masses; but sometimes, also, it is composed of slender, flexible leaves of no great consistency; it may be cut with a knife, is soluble in acids with effervescence, and the solution appears clear and colourless. It often, according to Mongez, contains aerated manganese, and may be easily distinguished from all the other gold ores by exposure to the fire. For the gold readily melts by the assistance of the lead which is present, and exudes through the mass into small globules. All the specimens are not equally rich in gold. Baron Born, in his letter to Mr. Ferber, enumerates the following varieties: 1. The ore of gold mineralized with galena, iron, and volatile particles. It is lamellated, gray, composed of small, flexible, brilliant plates, as above described. It is found among red felt spar, or fat quartz. 2. Gold mixed with the gray silver ore, or molybdena, or antimony. 3. Gold mixed with iron and sulphurated arsenic. Its texture is filamentous, and its colour yellowish. It slightly resembles the arsenical silver ore, mineralized by the reddish blend.

The auriferous ore of Nagayac, urged with the blow-pipe upon the charcoal, liquefies, and affords a white globule resembling silver, which is brilliant and malleable. Borax dissolves it without effervescence, or change of colour. Microscopic salt attacks it with effervescence, and assumes an obscure red colour, which disappears by continuing the fusion for a certain time. A metallic globule is perceived on the surface of the flux.

For other remarks on the treatment of gold and its ores, see the article GOLD. The new process of amalgamation, invented by Baron Born, has very much engaged the attention of mineralogists; for which reason, as well as for its own intrinsic value, I shall here give an account of the process, from Raspe's translation of the Baron's work on this subject*.

The amalgamation of gold and silver ores, in large operations, as well as in smaller assays, requires the following distinct operations:

- Stamping, grinding, and sifting.
- Calcination, and repeated grinding and sifting.
- Trituration.
- Washing of the residuum.
- Eliques of the amalgama.
- Heating of the same.
- Distillation of the quicksilver pressed from the amalgama.
- Refining of the heated quicksilver; and lastly,
- Management, use, and refining of such residua as still appear to contain some of the nobler metals.

Stamping, grinding, and sifting.

By these operations the picked ores, reguli, black copper, and reguline mixtures (peiss) of metals and semi-metals are reduced into fine powder; and their surfaces being thus increased, they mix and calcine better with the common or

* See the Chemical Journal, iii. 63.

rock salt, which is added to them; otherwise, the calcining fire and the air could not act sufficiently on the grosser particles, nor could the vitriolic and marine acids * properly penetrate them, or a perfect desulphuration and decomposition of such substances be brought on, in which the gold and silver particles are disguised.

These operations are performed at Glasshutte, near Schemnitz in Hungary, in dry stamps and mills; but at Joachimsthal in Bohemia, wet stamps have been substituted, by which means the loss of dust unavoidable in the dry grinding, and also the injury otherwise done to the health of the workmen, are prevented.

Calcination.

Sulphur can be expelled from ores in open fire and in closed vessels, but imperfectly, unless some proper substance be added. Thus, for example, corrosive sublimate is used in order to separate the sulphur from some ores; in this case the concentrated marine acid unites with the metallic, semi-metallic, and soluble earthy particles, passes into the receiver with the arsenic and antimonial calx in the form of butter, and the disengaged quicksilver sublimes with the disengaged sulphur in the form of cinnabar.

From this an idea may be formed of the calcination of those ores, which, besides particles of native metal, contain disguised gold and silver, which would never be got entirely by washing or other mechanical contrivances, without some chemical assistance. This is their calcination. By fire and air it decomposes the ores, expels the sulphur, puts the metallic and semi-metallic particles into a calciform state, and, freeing the noble metals from their disguises, exhibits them naked in their metallic form.

If there be sulphur enough, or even a superabundance of it, calcination will produce this desirable effect without any other addition. But as the vitriolic acid acts on the ores, and disengages the gold and silver particles only in proportion as it is produced from the sulphur in more or less quantity, it is safer to depend on the marine rather than the vitriolic acid: and though common or rock salt, added in the process of amalgamation of well calcined ores, answers this end in some respects, yet it will serve better when mixed in proper proportions with the earthy or metallic ores before they go to the calcining fire, thus undergoing with them a similar calcination. The quantity in which it is to be added must be determined by experience. When picked and halvan ores are calcined* with common salt, the sulphur and arsenic, if any, begin first to be disengaged. Part of the sulphur flies off undecomposed, a great part is converted into phlogiston and vitriolic acid, which last, uniting with the alkaline and metallic earths of the base metals and semi-metals, but in particular with the mineral alkali of the common salt, forms with the first, different earthy and metallic (more or less soluble) neutral salts, and with the last, Glauber's salt. The marine acid, thus disengaged begins now to act like the vitriolic acid, and is absorbed equally by the earths and the metallic calces.

* The vitriolic acid is produced in the act of calcination, by the decomposition of the sulphur contained in the ores, and the marine acid proceeds from the common salt, which is purposely added to the ores, and which is decomposed by the vitriolic acid. A Glauber's salt is formed by the union of the last mentioned acid with the bases of the common salt; and the marine acid, thus set at liberty, attacks, dissolves, and unites with the earthy matter, and also with the imperfect metals of the ores, by which means the particles of gold and silver are freed from their disguise or heterogeneous coverings, and laid open to, and fitted for combination with the quicksilver. This in few words the theory of the process.

The marine acid consequently penetrates the alkaline and metallic earths more completely than the vitriolic alone; for if there be salt enough, it decomposes all the vitriolic, earthy, and metallic neutral salts, by its different elective attractions, forming therewith various new deliquescent and very soluble earthy and metallic neutral salts, by which all the disguised gold and silver particles are disengaged, laid bare, and fitted for amalgamation.

When auriferous, or silvery reguline mixtures of base metals and semi-metals* (speifs) undergo calcination, fire and air will produce it in part, but slowly and imperfectly; whereas with common salt, or properly its acid, it succeeds quicker and better. There is no sulphur here, nor its acid, to decompose the salt and disengage its acid; but common salt decomposing by continued heat, its acid is as it were phlogisticated by the action of the fire, separates from its alkaline basis, and acts immediately as a solvent of the metallic and semi-metallic particles. The elective attraction of these metals and semi-metals seems even to assist the decomposition and power of the salt.

The different mixtures of these reguli (speifs) account for the different muriatic, metallic, and semi-metallic neutral salts. For instance, the reguli produced by the fusion of the Hungarian fallow, or gray copper ores, consist of antimonial regulus, copper, gold, and silver, and sometimes also of some arsenic and iron, which in the reguli of common antimonial gray copper ores, is but in a very inconsiderable proportion. The muriatic acid, disengaged from the salt, unites (gold and silver excepted) with the other metals and semi-metals, which by calcination leave the gold and silver bare and undisguised.

The same thing happens in the calcination of auriferous or only silvery black coppers. By the addition of common salt, the copper, iron, arsenic, and sometimes the antimonial particles are not only calcined, but also most of the antimony and arsenic is volatilized and destroyed.

The cobalt reguli produced in the treatment of arsenical cobalt and silver ores, contain very often a great quantity of bismuth. The calcination with common salt acts upon them in a similar manner; but should they abound in bismuth, which is exceedingly fusible, this semi-metal must be taken out by eliquation before they can be well calcined, otherwise the bismuth would run, and, if not wholly prevent, yet very much hinder the calcination of the other metallic and semi-metallic particles.

In calcining reguline mixtures, which abound in antimony, and particularly in arsenic, it has been frequently found that more or less quantities of silver and copper are carried off by the antimonial and arsenical butter, which arises from the marine acid, chiefly when the calcining heat has been too sudden and brisk for the purpose of a quick calcination of the antimony, and expeditious expulsion of the arsenic; for these volatile semi-metals acquire, by the muriatic acid, a much greater than their natural power to carry off and volatilize even the finest metals.

Whatever these reguline mixtures are, or may be, they must have gone through the stamps and mills, and have been completely pulverised before they can be committed to the calcining fire, which is a flaming fire kept up by the worst of fuel; or to the calcining furnace, which consists of two hearths, which, taken together, are 11 or 12 feet by five, of a grate, smoke and dust chambers, communicating with a flue, and sliding dust-stoppers or dust dampers.

* The reguline mixtures are produced in the fusion of cobaltic, arsenical, and antimonial ores.

The proportion and mixture of the picked and halvan or stamp-stuff is (in Hungary) determined by and depends upon the respective produce of the mines and stamps, which is commonly two in three; and with regard to the silver, upon their average produce. The proportion of the salt is regulated and determined by the more or less quantity of the sulphur of the said picked and halvan ores.

Thus, for example, a whole work, parcel, or stem of a calcining furnace in the quick-mills in Lower Hungary, consists of 30 cwt. one-third or 10 cwt. of which are pulverised picked ore, and two-thirds or 20 cwt. pulverised stamp or halvan-ore. Sometimes it consists of two-fifths of the former and three fifths of the latter; and in that proportion it contains, upon an average, three and a half, three and three-quarters, or four ounces of silver per cwt. To such a mixture they generally add eight per cent. of rock-salt*.

The calcination of speiss or reguline mixtures of base metals and semi-metals, of silvery black coppers, and of leadish ores, requires, over and above the salt, an addition of quick-lime, from four to ten and twelve per cent. For these metallic mixtures otherwise rise amazingly in the calcining heat, and the speiss and black coppers are in particular apt to turn clammy, and to leave clots in which many particles remain uncalcined; but both these inconveniences are counteracted by the lime. It prevents the immediate contact of the metallic particles, and their running in the calcining fire: moreover, as it increases the surface of the whole mixture, the single parts of the same are more effectually acted upon, calcined, and laid bare by the fire, air, and muriatic acid.

Even the silver regulus, and raw-stone, and the lead and copper reguli, bear a moderate addition of lime.

When the furnace is properly heated, and the doors of the dust-chambers, and the sliding-dampers, or dust-catchers of the flue, are shut, the whole parcel of ore (viz. 30 cwt.) is run by wheel-barrows on the flat top of the furnace, when having been equally spread into an even surface, the proper proportion of salt and lime is sifted over it, and the whole is turned and worked with iron rakes and crooks, in every direction, until the whole is perfectly and equally mixed. Thus prepared, it is spread into a square surface, and marked into equal divisions, which, in due succession, are let down (in 8 cwt. parcels) on the upper hearth, by means of a funnel, which opens upon it through the lower vault or floor of the furnace. On this hearth it must be spread and extended equally, that the moisture of the stamp or halvan-ore may be expelled, before it is shoved down on the lower hearth: after which the upper hearth is immediately filled again with another quantity, that exsiccation and calcination may be performed at the same time, by the same fire.

In the calcination, the following phenomena take place: on the surface of the picked and halvan-ores, when brought on the lower hearth, and stirred, an undulating motion is observed, and a volatile sulphureous acid smell is perceived; after which the sulphur begins to disengage itself burning, covering the whole (when the ores are very sulphureous) with a blue flame, and flying off at last in the form of a whitish thick suffocating smoke.

Whilst the sulphur is thus disengaged and decomposed in a low or gentle fire, the vitriolic acid, thence produced, decomposes the common salt, combines

* If pan-salt should be used, and prove of an inferior quality on account of fixed ammoniac (*calce salita*) and magnesia, left in it by too brisk boiling, &c. then the proportion must be different. Eight per cent. of pan-salt will do for silver ore; but copper regulus frequently requires ten per cent. and black copper twelve per cent.

with its mineral alkali, and disengages the marine acid, which presently unites with the alkaline and metallic earths. At this time the ore begins to clot, to rise, extend, and increase in bulk and surface. It begins to look like wet ashes and to diffuse a mixed, sulphureous, saline, acid smell, which proceeds from a lighter whitish or grayish blue smoke flying off from the surface.

From this instant the fire and furnace may be kept a little brighter, yet the ore must be continually stirred and turned over from one side of the furnace to the other; otherwise it would be calcined unequally, and some particles would remain undecomposed. If the furnace and fire were kept too bright, the sulphur, arsenic, and saline acid particles, too briskly expelled, would unavoidably carry along with them, and volatilize many other, nay even metallic particles*.

When the sulphur begins to disengage, the ore changes its colour; it changes again when the calcination is over at its rising and subsidence. The sulphureous acid smell disappears when the ore that had been rising begins to sink, and the clotting ceases, for then part of the muriatic acid flies off. On taking a ladle full of it for proof, or even on smelling the whitish rarefied smoke near the back-door of the furnace, the smell of pure marine acid, or of volatile spirit of salt, is perceived.

Most ores and mixtures of ores, chiefly when containing a great proportion of pyrites, or when there happens to be sulphurated copper ore, shew at this period a luminous phosphoric appearance, when suddenly taken from the hearth, and immediately examined in the dark. In a moderate heat and cold weather, they likewise shew, during the stirring, bright luminous sparks, flying and scattering about like fire-work.

When the sulphur is sufficiently expelled, and part of the marine acid is gone; when the whole begins to subside, and the clotting to be less; and when all the above-mentioned phenomena have appeared, then the calcination is deemed to be perfect.

The colour of the calcined ores and halvans is generally red, reddish gray, dark red, or red-brown, according to the proportion of the earthy and metallic particles, or of the sulphur they contained. They are of a lighter and higher red when very earthy; brown when very coppery, or mixed with manganese; and yellowish red when lead prevails in their mixture.

Copper reguli, containing a much greater proportion of sulphur, must undergo a longer calcining heat than other mixtures of ores and halvans. When mixed with lead, or antimony and arsenic, they must be put to calcine not only with common salt, but also with a proportionate quantity of quick-lime, that the excess of muriatic acid may be taken from the butter of antimony and arsenic, and from the plumbum corneum which are produced during the calcination, and be absorbed by the lime, which prevents the untoward clotting of the particles.

The same cautions must be observed in the calcination of the reguline mixtures (speiss) of base metals and semi-metals, and of the silvery black coppers, for they also contain a considerable proportion of antimony and arsenic. If not calcined with lime, along with the common salt, they pack at the very instant the regulus of antimony and arsenic is calcined and volatilized, in the form of a

* Though the fire be ever so cautiously conducted, some particles of the ore will be carried off and lost. This chiefly happens in the first stage of the fire, for then during the stirring of the ore, some particles are taken up and carried away by the current of rarefied air, or during the rising of the mixture, by means of the sulphur and marine acid. This may be in some measure prevented by keeping the back-door of the upper hearth shut; by avoiding to stir the mixture while it duffs, &c. &c.

white

white very thick smoke, which is brought about very expeditiously by the disengaged marine acid.

The reguline mixtures (specifs) of metals and semi-metals, and the black coppers, containing little or no sulphur, the common salt calcined with them is decomposed by the action of the fire. The marine acid, thus set free, promotes their calcination, and forms with their calces different perfect or imperfect neutral salts, disengages the disguised gold and silver particles, whilst the mineral alkali remains free and in a caustic state: for, in the dry way, the marine acid leaves its alkali, and combines with the metals and their calces; but, by subsequent solution in water, it returns to the alkali, forming again with it common salt, and consequently lets go the metals, semi-metals, and earthy particles, before in solution.

In the calcination of these metallic mixtures and the copper reguli, the before-mentioned luminous phosphoric appearance does not take place; but the flame which passes over them affects various colours, and in particular the red and blue, both owing to volatilized particles of copper.

When antimonial stone, copper reguli, and reguline mixtures of metals and semi-metals are put to calcine, the antimony calcines first, forming a white calx in the flues and other passages; arsenical mixtures diffuse a white smoke and garlic smell; those which abound in lead and zinc (which last require a stronger and longer fire) produce saturnine zincous smoke and white flowers.

When the calcination of these metallic mixtures is perfected, and the remainder is cooled, their calces appear brownish gray, or dark gray; and those of the stone and copper reguli of a more or less saturated red colour, except those which abound in lead.

The surest symptoms, however, of their perfect calcination, are collectively the rising and sinking of the mixtures, their colour, and the acrid smell of the marine acid. Then only the gold and silver particles may be deemed to be fully disengaged.

Sifting and grinding after calcination.

The grinding and sifting of the stuff is as necessary after as before calcination, because the stamp and halvan-stuff, which is mixed up with the picked ore, could not be sifted or ground previous to its calcination, on account of its moisture. This further grinding and sifting serves likewise fully to pulverize and equalize the clots of the reguline mixtures (specifs) of metals and semi-metals, and of the copper reguli.

If these coarser particles were suffered to remain as they are, they might still disguise many gold and silver particles, and guard them against amalgamation.

This repeated grinding and sifting may be dispensed with when the whole stuff is of an equal size and sufficiently fine; but its clots will at any rate require examination, whether they be soluble in water or not, for those of leady and metallic mixtures remain insoluble. If soluble, and not leaving sharp coarse particles between the fingers, they want neither grinding nor sifting, but they must go through both these operations when insoluble, and when they betray such coarse particles on being rubbed between the fingers.

Trituration, boiling, and amalgamation of the calcined stuff.

By amalgamation we understand that mechanical and chemical operation, in which, by means of quicksilver, heat, uninterrupted motion, and successive contact of the particles,—gold and silver (previously disengaged from their disguises by calcination and pulverisation) are extracted from their earthy, metallic, or mineralized matrixes, and combined with quicksilver.

If the ores have been duly pulverised and calcined, the success of trituration or amalgamation mostly depends on the proper proportions of the quicksilver and water which are added to the stuff: it likewise depends on the goodness and construction of the stirring apparatus, by which the whole mixture is kept in constant motion and mutual contact. Even the degree of heat, and the quickness of the trituration or stirring, contribute to the quicker and perfect amalgamation.

To determine the quantity of quicksilver, the weight and bulk of the calcined stuff are to be considered. The lighter the stuff, the more voluminous it will prove, and consequently the gold and silver will be the more dispersed. In this case the quantity of quicksilver must be proportioned to the mass. Thus, for example, 2 cwt. of picked ore and halvans are more bulky than 2 cwt. of calcined copper regulus or other reguli. The former, therefore, require a larger quantity of quicksilver.

Both in small and great operations, experience has determined, that an excess of quicksilver is never hurtful, and that, on the contrary, a scanty proportion is attended with losses. It may be taken in the proportion of one to two, that is 1 cwt. of quicksilver to 2 cwt. of stuff. In this proportion it does not increase the cost of washing and pressing, nor is any loss of quicksilver incurred; the full produce of noble metal is thus secured, and the residuum is left poorer.

The vessels or boilers, in which the quicksilver and stuff are triturated, are of copper, of an inverted conical form, and with a concave bottom. No boiling heat required: a heat of 50° or 60° is sufficient.

No more water is required than what will soak into and make the stuff liquid. Excess of water makes the quicksilver sink too fast, and keeps the lighter and finer particles of the metals floating on the surface; which of course prevents the perfect success of the operation. On the other hand, too little water leaves the stuff too thick, which makes the stirring very troublesome; moreover, the evaporation of the water soon forms a dry and hard crust on the sides of the boiler, which is attended with loss of silver in the residuum. Experience must determine the proper respective measure of water.

The stirring apparatus is put into motion by means of a water-wheel.

The stirrers or stirring racks (which were at first made of copper, but have since been found to answer better when made of wood) are circular segments corresponding with the sides and bottom of the boiler.

Experience only can determine how long the respective stuffs must be triturated with quicksilver. It has been found that some stuff yields its gold and silver to the quicksilver, perfectly and completely within eight or ten hours; other mixtures require a trituration of 12 or 15 hours. Excess of time or longer trituration is never hurtful; too little of it will often lessen the produce.

Washing of the triturated leavings, or residuum.

The object of the trituration already described, was to unite the gold and silver particles of the calcined stuff into an amalgama with quicksilver: the object of this washing, is the separation of this rich amalgama from the leavings or residuum.

This washing is performed in a large tub, of a conical form, with a rake within it, contrived so as to be thrown into a rotatory motion, by a water-wheel, or by hands; with side cocks for drawing off the water; and with a bottom cock for tapping off the amalgama or quicksilver.

The

The particles of quicksilver and amalgama, kept floating in the whole liquid mass, by the continual rotation of the rake, sink by their gravity, and collect in the concave bottom of the tub, above the cock; but the remaining stuff or ore and stony matter, being much lighter, is kept floating. When the whole has been sufficiently stirred about in this manner with the water, the bottom cock of the washing-tub is opened, and the quicksilver and amalgama are thereby let out; after which one (or more) of the side cocks (which are fixed at different heights) is opened to let out the thin liquid stuff*.

Eliques of the quicksilver and amalgama.

The quicksilver, triturated with rich stuffs, is strained through a kind of filtrum, for the purpose of bringing the gold and silver particles into a smaller compass, and of separating them from the excess of quicksilver; although the whole can never be separated but by fire.

This is done by means of a box, on the circular opening of which lies an iron ring, to which is fixed a bag of linen damask. The quicksilver (its surface having been previously cleansed with a sponge from any muddy water or stuff that might adhere to it) is poured in small quantities into this bag by one person, whilst another presses it with his hands, until the ball of amalgama, collecting and forming apace, does no longer yield any quicksilver. When the ball becomes too big for pressure with two hands, it is taken out, and another is formed in the same manner, until all the quicksilver is gone through the bag. The balls of amalgama are put into a wooden box.

The quicksilver which has been strained through the bag (and which always contains from 20 to 30 penny-weights of gold and silver per cwt.) is collected in a reservoir under the box, and serves again for trituration with fresh quantities of ore†.

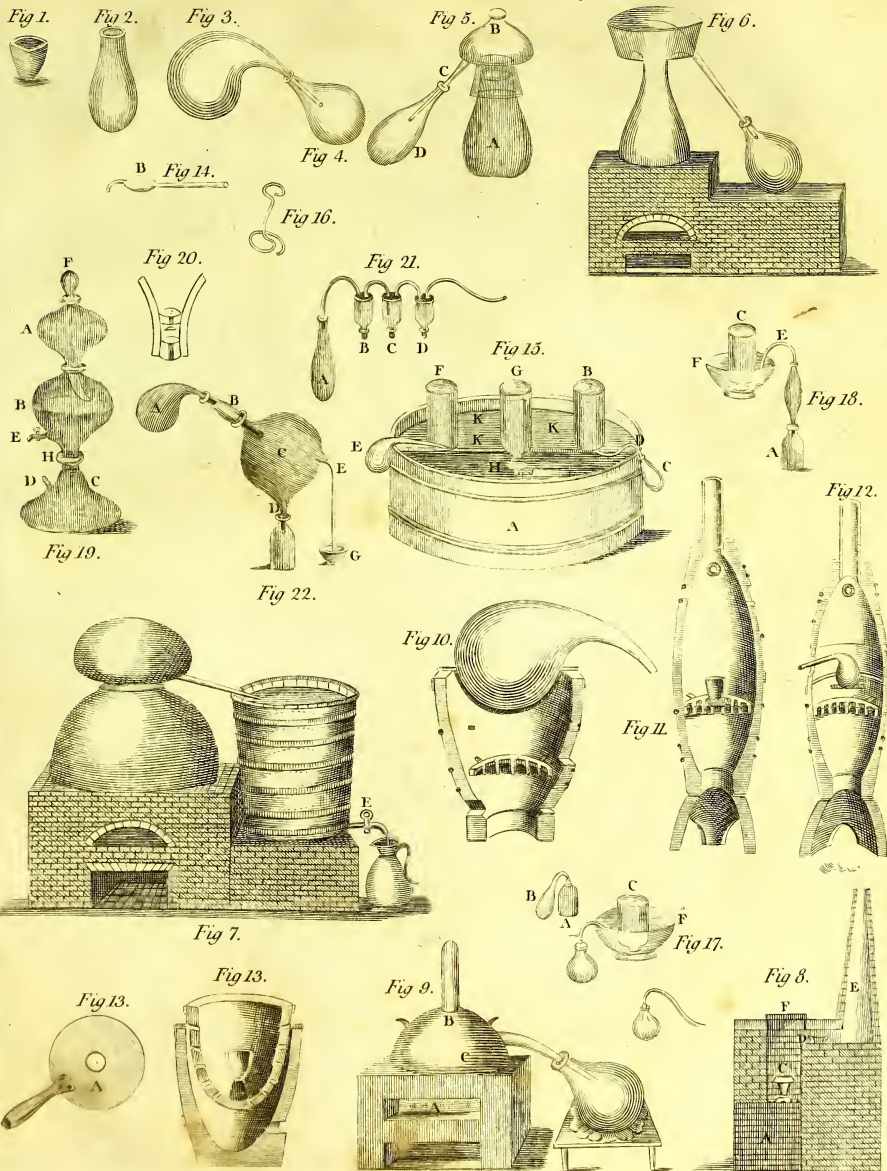
Heating and sublimation or distillation of the amalgama.

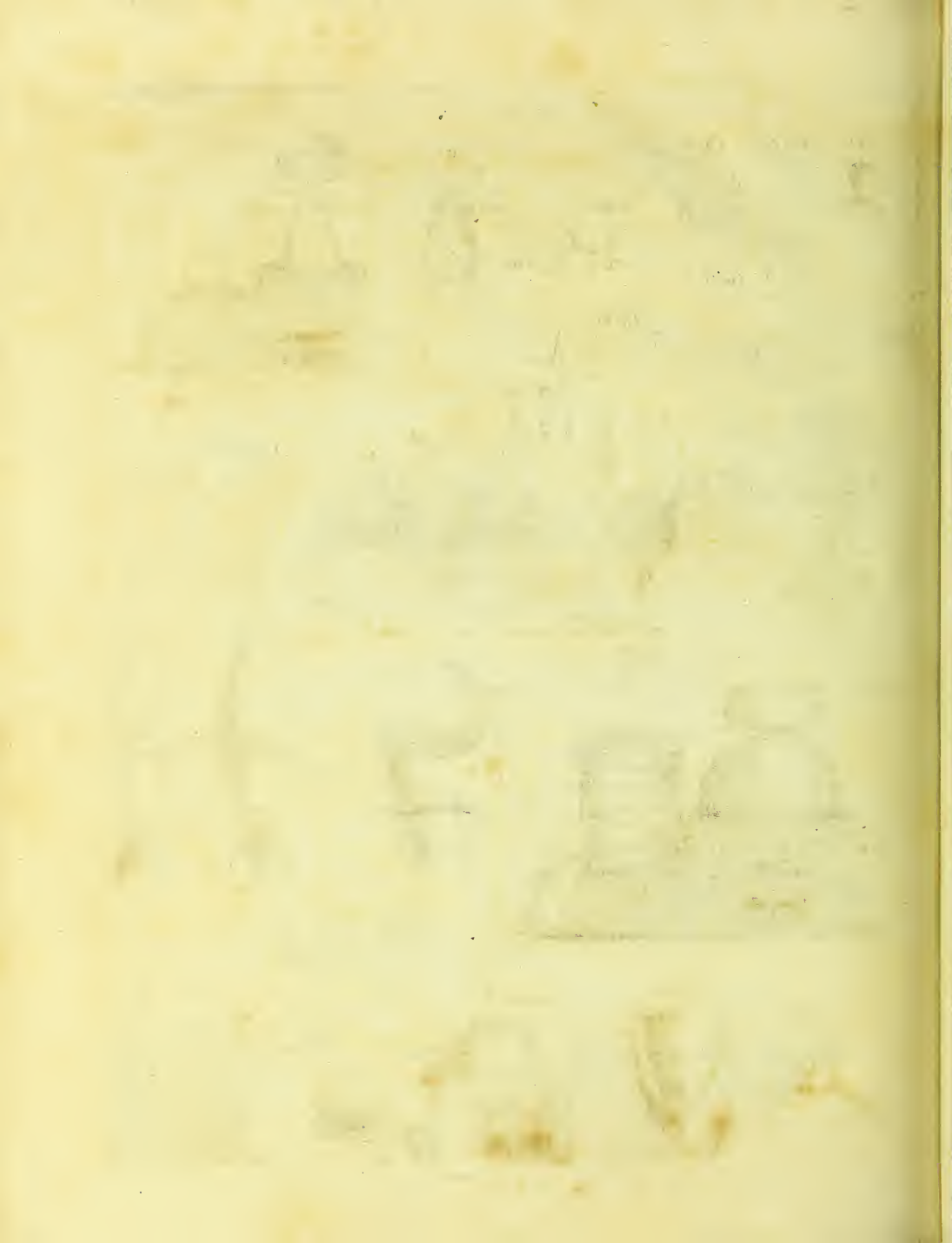
The amalgama balls, obtained by pressing or eliquating the quicksilver, consist (according to the different degrees of pressure they underwent) of one part silver, and four, five, or six parts quicksilver. This is expelled from them by fire in close vessels. It is a distillation *per descensum*, performed in large cast-iron pots put over each other. The fire is kept up for five or six hours. The heat acting through the pots on the amalgama, volatilizes the quicksilver, which rising in the form of vapour, and finding no passage in the inverted upper pot, is forced down into the lower one, and collects there by the way of distillation, being condensed and precipitated by the coolness that is constantly kept up by cold water applied to the outside of the lower pot or receiver.

When no copper has been revived, and the amalgama has been perfectly treated, all the quicksilver is recovered without loss, and the balls are white like silver, and mossy on their surfaces. If coppery, they have a reddish cast, and are brownish if the copper has undergone a superficial calcination. If leady, which is seldom the case, they shew a dark pearl gray colour.

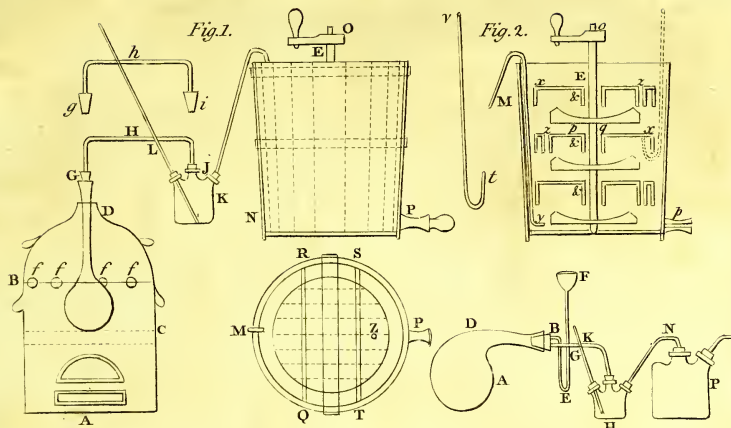
* Cold amalgamation (of which an account will be given in a note subjoined at the end of this article) has been successfully introduced in Bohemia, in place of this warm amalgamation in copper boilers.

† It is remarkable, that the greatest part of the gold and silver remains suspended in the quicksilver, when pressed through warm as it comes from the washing tub; and that, when left undisturbed to cool, the amalgama congeals and sinks to the bottom. In freezing cold the amalgama appears crystallized internally, and seems, like antimony, to consist of short crystalline fibres, crossing each other, and even appearing on its surface.

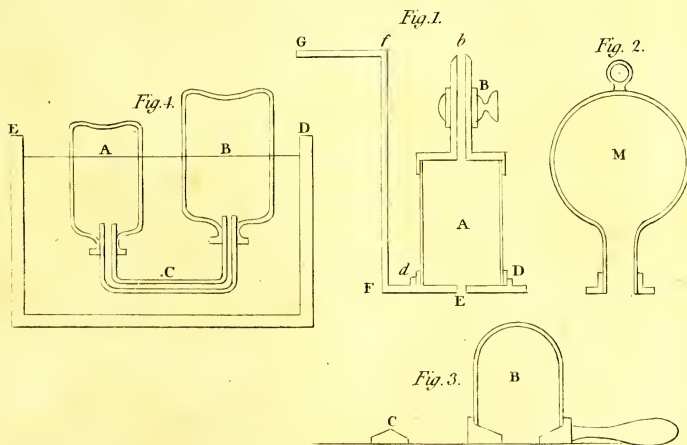


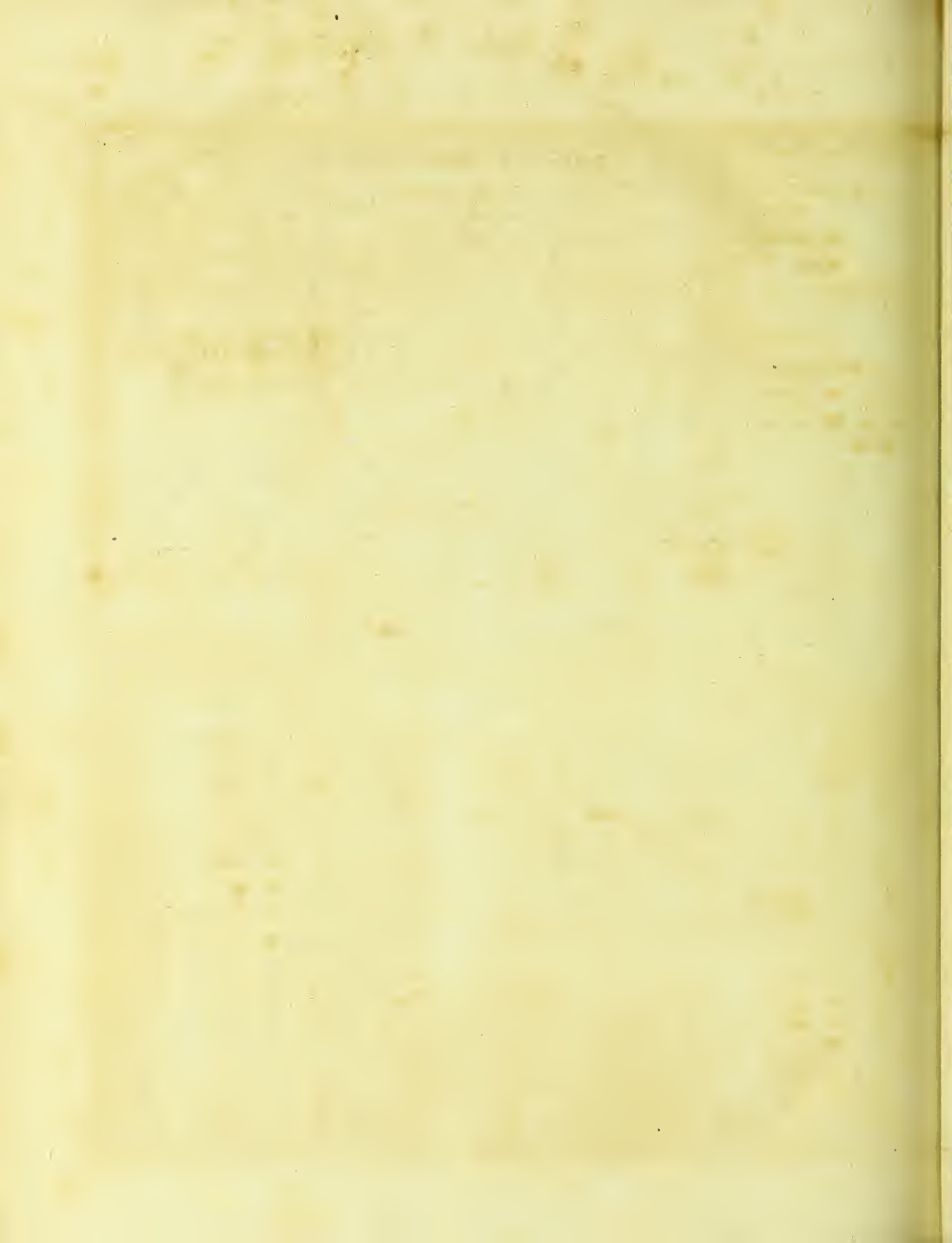


Apparatus for Bleaching Page 25.



The Eudiometer of Cavendish. Page 327.





I. TABLE OF THE CHARACTERS TO BE MADE

Simple Substances which can exist in the aeriform state in the ordinary temperature of the Atmosphere, and which entering into the composition of an infinity of substances demand a great simplicity of their Characters.

Alkalies which are as yet considered as simple Substances

Simple Earths

Combustible Simple Substances, commonly called Inflamable Substances.

Light.

Caloric Matter of Heat.

Oxygen. Base of Filad. Air.

Azot. Base of Nitated Air, or Mofette.

Characters to express such new and simple Substances as may be discovered.

Potash. Caustic fixed Alkali.

Soda. Caustic Mineral Alkali.

Barytes. Ponderous earth.

Lime. Calx.

Magnesia.

Alumine. Argillaceous earth.

Silice. Quartz.

Hydrogen. Base of Inflamable Air.

Carbon. or pure Charcoal.

Sulphur.

Phosphorus.

Characters to express such new combustible substances as will be discovered.

METALLIC SUBSTANCES.

Metals reducible by heat alone.

A metal in the liquid State in the ordinary temperature of the atmosphere.

Malleable Metals.

Metals not malleable.

Acidifiable Metals.

Platina.

Gold. Aurum.

Silver. Argentum.

Mercury. Hydrargyrum.

Tin. Stannum.

Copper. Cuprum.

Lead. Plumbum.

Iron. Ferrum.

Zink. Zincum.

Manganese. Magnesium.

Nickel. Nicolum.

Bismuth. Bismuthum.

Antimony. Stibium.

Cobalt. Kobaltum.

Arsenic. Arsenicum.

Molybden. Molybdenum.

Tungstein. Tungstenum.

II. TABLE. COMBINATIONS OF CALORIC. with different Simple Substances, producing the Solid, Liquid, and Aeriform States.

	Solid.	Liquid.	Aeriform.		Solid.	Liquid.	Aeriform.		Solid.	Liquid.	Aeriform.
Azot.	/	✓	✓	Copper.	C	C	C	Pyro-lactureous Radical.	F	F	F
Potash.	△	△	△	Lead.	P	P	P	Ovalic Radical.	O	O	O
Soda.	△	△	△	Iron.	F	F	F	Gallic Radical.	G	G	G
Barytes.	▽	▽	▽	Zink.	Z	Z	Z	Giric Radical.	C	C	C
Lime.	▽	▽	▽	Manganese.	M	M	M	Malic Radical.	M	M	M
Magnesia.	▽	▽	▽	Nickel.	N	N	N	Benzoic Radical.	Bz	Bz	Bz
Alumine.	▽	▽	▽	Bismuth.	B	B	B	Pyro-hymic Radical.	E	E	E
Silice.	▽	▽	▽	Antimony.	Sb	Sb	Sb	Camphoric Radical.	Cp	Cp	Cp
Hydrogen.	○	○	○	Arsenic.	As	As	As	Lactic Radical.	L	L	L
Carbon.	○	○	○	Molybden.	M	M	M	Saccho-lactic Radical.	Sf	Sf	Sf
Sulphur.	○	○	○	Tungstein.	T	T	T	Formic Radical.	Em	Em	Em
Phosphorus.	○	○	○	Muriatic Radical.	M	M	M	Prylic Radical.	P	P	P
Gold.	○	○	○	Boracic Radical.	B	B	B	Sebacic Radical.	Sb	Sb	Sb
Platina.	○	○	○	Fluoric Radical.	F	F	F	Bomhic Radical.	Bb	Bb	Bb
Silver.	○	○	○	Succinic Radical.	S	S	S	Lithic Radical.	L	L	L
Mercury.	○	○	○	Acetous Radical.	A	A	A	Ether.	E	E	E
Tin.	○	○	○	Tactareous Radical.	T	T	T	Alkohol.	A	A	A

OF IN CHEMISTRY. By Mefs. Haffenfratz and Adet.

acids which we do not yet know, but whose nature we expect to be able to discover.

M	Muriatic.
B	Boracic.
F	Fluoric.
S	Succinic.
A	Acetic.
T	Tartaric.
P	Pyro-tartaric.
O	Oxalic.
G	Gallie.
C	Citric.
M	Malic.
Bz	Benzoic.
P	Pyro-lignic.
Pm	Pyro-mucic.
Cp	Camphoric.
L	Lactic.
SL	Saccho-lactic.
Em	Formic.
P	Prussic.
SA	Sebacic.
BA	Bombee.
L	Lithic.

Radical

Compound bodies which are not acidifiable bases and whose component principles are very little known.

General Characters.

E	Ether.
A	Alcohol.
O	Fixed Oil.
OV	Volatile Oil.
B	Bitumen.
M	Mucus.
△	Alkalies.
▽	Earths.
C	Combustible Substances.
C	
○	Metallic Substances.
□	Compound Acidifiable Bases.
◇	
◇	Non-Acidifiable compound Substances.

TABLE. THE KNOWN COMBINATIONS OF OXYGEN & CALORIC WITH DIFFERENT SUBSTANCES.

ous Gas.	Concrete Oxygenated Muriatic Acid.	M	Liquid Sebacic Acid.	SA
ous Acid Gas.	Concrete Boracic Acid.	B	Liquid Bombee Acid.	BA
ous Acid.	Fluoric Acid Gas.	F	Oxyd of Tungsten.	T
ic Acid.	Concrete Succinic Acid.	S	Tartaric Acid.	T
ogenated Nitric Acid.	Liquid tartareous Acid.	T	Oxyd of Molybden.	ML
	Concrete tartareous Acid.	T	Concrete Molybdic Acid.	ML
	Liquid Pyro-tartareous Acid.	P	Oxyd of Arsenic.	AS
	Liquid Acetous Acid.	A	Concrete Arsenic Acid.	AS
or of Water.	Acetous Acid Gas.	A	Oxyd of Cobalt.	K
onic Acid Gas.	Liquid Acetic Acid.	A	Oxyd of Antimony.	SB
shureous Acid Gas.	Concrete Oxalic Acid.	O	Oxyd of Bismuth.	B
shureous Acid.	Liquid Gallie Acid.	G	Oxyd of Nickel.	N
iquid Sulphuric Acid.	Liquid Citric Acid.	C	Oxyd of Manganese.	M
crete Sulphuric Acid.	Liquid Malic Acid.	M	Oxyd of Zinc.	Z
crete Phosphoreous Acid.	Concrete Benzoic Acid.	Bz	Oxyd of Iron.	F
id Phosphoreous Acid.	Liquid Pyro-ligneous Acid.	P	Oxyd of Lead.	P
id Phosphoric Acid.	Liquid Pyro-mucous Acid.	Pm	Oxyd of Copper.	C
id Muriatic Acid.	Concrete Camphoric Acid.	Cp	Oxyd of Tin.	S
iatric Acid Gas.	Liquid Lactic Acid.	L	Oxyd of Mercury.	H
enated Muriatic Acid Gas.	Concrete Saccho-lactic Acid.	SL	Oxyd of Silver.	A
id Oxygenated Muriatic Acid	Liquid Formic Acid.	Em	Oxyd of Gold.	G
	Prussic Acid Gas.	PS	Oxyd of Platina.	P

TABLE IV. COMBINATIONS OF TWO SUBSTANCES.
Caloric forms a third in some of these Compositions.

Ammoniacal Gas.....		Sulphuret of Alumine.....		Sulphuret of Antimony.....		Amalgam of Silver.....	
Concrete Ammoniac.....		Sulphuret of Gold.....		Sulphuret of Cobalt.....		of Copper.....	
Carbonated Azotic Gas.....		Sulphuret of Silver.....		Sulphuret of Arsenic.....		of Tin.....	
Sulphurated Azotic Gas.....		Sulphuret of Mercury.....		Sulphuret of Molybden.....		Alloy of Tin & Copper.....	
Carbonated Hydrogen Gas.....		Sulphuret of Tin.....		Phosphuret of Lead.....		of Tin & Lead.....	
Sulphurated Hydrogen Gas.....		Sulphuret of Copper.....		Phosphuret of Iron.....		of Iron & Manganese.....	
Phosphorated Hydrogen Gas.....		Sulphuret of Lead.....		Alloy of Platina & Gold.....		of Iron & Nickel.....	
Sulphuret of Potash.....		Sulphuret of Iron.....		of Platina & Silver.....		Carburet of Iron.....	
Sulphuret of Soda.....		Sulphuret of Zinc.....		of Gold & Silver.....			
Sulphuret of Barytes.....		Sulphuret of Nickel.....		of Gold & Copper.....			
Sulphuret of Lime.....		Sulphuret of Bismuth.....		Amalgam of Gold.....			

TABLE V. NEUTRAL SALTS COMPOSED OF THREE SUBSTANCES.

Caloric is not expressed, because they are all supposed to be in the solid state. The Ammoniacal State are composed of four Substances.

Calcareous Acetat.....		Calcareous Camphorat.....		Acidulous Oxalat of Potash.....		Sulphat of Lime.....	
Acetat of Alumine.....		Citrat of Soda.....		Phosphat of Potash.....		Acidulous Sulphat of Alumine.....	
Acetat of Magnesia.....		Ammoniacal Citrat.....		Phosphat of Soda.....		Sulphat of Alumine.....	
Acetat of Potash.....		Calcareous Citrat.....		Ammoniacal Phosphat.....		Sulphat of Alumine with excess of base.....	
Acetat of Soda.....		Fluat of Potash.....		Phosphat of Lime.....		Sulphat of Magnesia.....	
Acetat of Copper.....		Fluat of Ammoniac.....		Phosphat of Iron.....		Sulphat of Silver.....	
Acetat of Iron.....		Fluat of Lime.....		Phosphite of Soda.....		Sulphat of Mercury.....	
Ammoniacal Acetide.....		Formiat of Soda.....		Prigniat of Iron.....		Sulphat of Tin.....	
Acetie of Potash.....		Ammoniacal Formiat.....		Pyro tartrite of Potash.....		Sulphat of Copper.....	
Calcareous Acetide.....		Calcareous Formiat.....		Pyro mucite of Soda.....		Sulphat of Lead.....	
Bombiat of Potash.....		Lactat of Soda.....		Pyro lignite of Ammoniac.....		Sulphat of Iron.....	
Ammoniacal Bombiat.....		Ammoniacal Lactat.....		Saccho-lat of Potash.....		Sulphat of Zinc.....	
Calcareous Bombiat.....		Lactat of Lime.....		Sebat of Soda.....		Sulphat of Manganese.....	
Carbonat of Potash.....		Gallat of Potash.....		Sulphite of Potash.....		Sulphat of Nickel.....	
Carbonat of Soda.....		Malat of Potash.....		Sulphat of Potash.....		Sulphat of Bismuth.....	
Ammoniacal Carbonat.....		Muriat of Potash.....		Acidulous Sulphat of Potash.....		Sulphat of Antimony.....	
Calcareous Carbonat.....		Muriat of Soda.....		Sulphat of Potash with excess of base.....		Sulphat of Cobalt.....	
Barytic Carbonat.....		Ammoniacal Muriat.....		Sulphat of Soda.....		Sulphat of Arsenic.....	
Magnesian Carbonat.....		Barytic Muriat.....		Acidulous Sulphat of Soda.....		Sulphat of Molybden.....	
Carbonat of Iron.....		Muriat of Iron.....		Sulphat of Soda with excess of base.....		Sulphat of Tinstein.....	
Benzoat of Potash.....		Oxygenated Muriat of Soda.....		Sulphat of Ammoniac.....		Succinat of Potash.....	
Ammoniacal Benzoat.....		Nitrat of Potash, or Nitre.....		Acidulous Sulphat of Ammoniac.....		Arseniat of Potash.....	
Calcareous Benzoat.....		Nitrat of Soda.....		Sulphat of Ammoniac.....		Arseniat of Potash with excess of base.....	
Borat of Soda.....		Ammoniacal Nitrat.....		Sulphat of Ammoniac.....		Molybdat of Soda.....	
Ammoniacal Borat.....		Barytic Nitrat.....		Sulphat of Ammoniac with excess of base.....		Ammoniacal Tinstat.....	
Calcareous Borat.....		Nitrat of Silver.....		Barytic Sulphat.....		Calcareous Tinstat.....	
Camphorat of Potash.....		Nitride of Potash.....				Lithiat of Potash.....	
Ammoniacal Camphorat.....		Oxalat of Potash.....					

THE JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION PUBLISHED WEEKLY CHICAGO, ILL., U.S.A.

DATE	VOLUME	NUMBER	PAGE	ARTICLE
1917	1	1	1	1
1917	1	2	2	2
1917	1	3	3	3
1917	1	4	4	4
1917	1	5	5	5
1917	1	6	6	6
1917	1	7	7	7
1917	1	8	8	8
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1917	1	10	10	10
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1917	1	97	97	97
1917	1	98	98	98
1917	1	99	99	99
1917	1	100	100	100

DATE	VOLUME	NUMBER	PAGE	ARTICLE
1917	1	101	101	101
1917	1	102	102	102
1917	1	103	103	103
1917	1	104	104	104
1917	1	105	105	105
1917	1	106	106	106
1917	1	107	107	107
1917	1	108	108	108
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1917	1	122	122	122
1917	1	123	123	123
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1917	1	125	125	125
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1917	1	132	132	132
1917	1	133	133	133
1917	1	134	134	134
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1917	1	136	136	136
1917	1	137	137	137
1917	1	138	138	138
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1917	1	141	141	141
1917	1	142	142	142
1917	1	143	143	143
1917	1	144	144	144
1917	1	145	145	145
1917	1	146	146	146
1917	1	147	147	147
1917	1	148	148	148
1917	1	149	149	149
1917	1	150	150	150







